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WSTF FILTER TEST PROGRAM
INTERIM REPORT

Interface Filter Tests on Test Specimens
Wintec P/N 15267-552 S/N 017
Wintec P/N 15267-556 S/N 009
Using Water as the Test Fluid

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LAS CRUCES, NEW MEXIC

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INTERFACE FILTER TESTS ON TEST SPECIMENS

Wintec P/N 15267-552 S/N 017
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USING WATER AS THE TEST FLUID

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1.0 INTRODUCTION

This interim report summarizes the results of tests conducted on two interface propellant filters. The tests were conducted, using deionized water as the test fluid and a mixture of A.C. coarse dust and iron pyrites as the contaminant, to establish a WSTF data baseline for comparison with tests conducted by Wintec Corporation, Inglewood, California. The tests were designed to determine the maximum sized particle passed by the filters and the relationship between the pressure drop across a filter test specimen and the amount of contaminant added upstream of the filter test specimen.

The tests were conducted as outlined in test directive TD-121-FTP-003, Revision B, dated October 23, 1968, and the letter of deviation approved January 8, 1969, by EP and NC (MSC Houston) and RD (MSC WSTF).

2.0 SUMMARY

During the period January 15 through January 21, 1969, two interface propellant filters (manufactured by Wintec Corporation, Inglewood, California) were subjected to a special contamination holding capacity test. The test specimens were identified as follows:

Wintec P/N 15267-552 S/N 017
Wintec P/N 15267-556 S/N 009

The tests were conducted as outlined in test directive TD-121-FTP-003, Revision B, as amended by a letter of deviation approved by EP and NC (MSC Houston) and RD (MSC WSTF). The tests were conducted using deionized water as the fluid media and a mixture of A.C. coarse dust and iron pyrites as the contaminant. The particle count data obtained on samples during the contamination addition portion of the test indicated that both filter specimens successfully met the following sample particulate criterion using iron pyrites as the identifiable contaminant.

Particle Count per 500 ml Sample

Size Range (Microns)	Maximum Number
0 - 50	Unlimited
50 - 75	100
75 - 100	10
Greater than 100	0

During the contaminant addition test on Wintec P/N 15267-552 S/N 017, the largest iron pyrite particle observed was in the 50 to 75-micron size range. The largest iron pyrite particle observed was in the 25 to 50-micron size range during the same tests on Wintec P/N 15267-556 S/N 009.

While flowing deionized water as the test fluid, the tests demonstrated the holding capacity of the filters up to 50 psid to be in excess of 4.0 grams of the A.C. coarse dust/iron pyrite mixture. The test specimen "net" Delta P versus quantity of contaminant added curves compare favorably with the Wintec Corporation test data obtained on Wintec test specimen P/N 15267-552 S/N 006. In addition to the above tests, the flow rate versus Delta P characteristics of the filter specimens were determined using "clean" deionized water.

3.0 TEST OBJECTIVES

Using deionized water as the test fluid, the tests were designed to: (1) establish the flow rate/Delta P characteristics of the filter using clean fluids, (2) evaluate the relationship between the amount of contaminant added to the upstream side of the filter and the resultant Delta P, and (3) evaluate the particulate passing characteristics of the filter while adding contaminants to the upstream side of the filter. The data will be used to establish a WSTF data baseline for comparison with tests to be conducted using live propellants as the test fluid and for comparison with data reported by the Wintec Corporation.

4.0 FILTER TEST SPECIMENS

The filter test specimens used in the conduct of the tests were identified as follows:

Identification Number	Serial Number
GF-525-AM-8 (Wintec P/N 15267-552)	017
GF-525-AM-12 (Wintec P/N 15267-556)	009

The filters were received packaged and certified clean to the requirements of LSP-14-0011 level N.

5.0 CONTAMINANT COMPOSITION

The A.C. coarse dust contaminant specified in TD-121-FTP-003, Revision B, was amended by the letter of deviation dated January 8, 1969, to be replaced with the following mixture which was purchased from Particle Information Service, Los Altos, California:

Particle Size (Microns)	Material	Percent by Weight
0 - 5	A.C. coarse dust	12 ± 2
5 - 10	A.C. coarse dust	12 ± 3
10 - 20	A.C. coarse dust	14 ± 3
20 - 40	A.C. coarse dust	23 ± 3
40 - 80	Iron pyrite	30 ± 3
80 - 200	Iron pyrite	9 ± 3

Figure 1 is a photograph of a portion of the contaminant mixture taken through a microscope showing A.C. coarse dust and iron pyrite particles. The iron pyrite particles in the mixture are sized to permit their use as an identifiable contaminant during the tests designed to establish the particle passing characteristics of the filters.

6.0 TEST PROCEDURE

6.1 Basic Test Procedure

The test procedure outlined in the test directive TD-121-FTP-003, Revision B, dated October 23, 1968, as amended by the letter of deviation by EP and NC (MSC Houston) and RD (MSC WSTF) was detailed in the operational checkout procedure OCP-121-FTP-003A used to conduct the tests.

The test procedure consisted of the following basic steps:

a. Demonstration of system cleanliness

(1) Assemble the test fixture using the tare filter designed to represent the test specimen.

(2) Load the test fixture with deionized water and flow water through the system at approximately 10 gpm for a minimum of 30 minutes.

(3) Adjust the flow to the nominal flow rate (3 gpm) for the filter specimen being tested. Sample the water through the sample port downstream of the test specimen a minimum of ten times to demonstrate the system meets the cleanliness requirement of no iron pyrite particles greater than 50 microns. An additional requirement of no fibers greater than 100 microns shall be considered in effect for the performance of paragraph d if the samples obtained in response to paragraphs a.3, b.2, and c.4 do not exhibit any fibers greater than 100 microns. The particle counts shall be made according to the following requirements:

Particle Count Requirements

1. The maximum sized iron pyrite particle and the particle count of all iron pyrite particles, according to the following size ranges, shall be reported as test constraint items:

Range (Microns)
10 - 25
25 - 50
50 - 75
75 - 100
> 100

2. In addition, the maximum sized particle of any material other than iron pyrites and the largest fiber shall be determined and reported.

NOTE: The results of this step must be acceptable to the NASA Test Operations Office (TOO) prior to performance of step b.

b. Determination of test specimen Delta P tare values

(1) Successively establish the flowrate of water to the following test values and record data.

Wintec P/N	Test Values (gpm)
15267-552	1, 2, 3, 4, 5
15267-556	1, 3, 5, 6, 8

(2) Re-establish the water flowrate to the nominal value (3 gpm). Sample the water through the sample port downstream of the filter test specimen a minimum of three times to confirm conformance of the particulate distribution to the requirements established in step a.3.

c. Determination of the filter test specimen flow rate versus Delta P relationship using "clean" water

(1) Install the filter test specimen.

(2) Establish the water flow rate to the nominal value (3 gpm). Sample the water through the sample port upstream of the filter test specimen.

NOTE: Samples taken upstream of the test specimen are not required to meet any cleanliness requirement.

(3) Successively establish the flow rate of the water to the test values listed in step b.1 and record data.

(4) Repeat step c.2 except sample the water through the sample port downstream of the filter test specimen a minimum of three times to confirm conformance to the particulate distribution of the requirements established in step a.3.

d. Determination of the contamination susceptibility of the test filter.

(1) Establish the water flow rate to the nominal value (3 gpm) and add the first increment of contamination as recommended below:

Quantities of contaminant to be used in the performance of the contamination susceptibility tests:

For all test specimens the contaminant (A.C. coarse dust/iron pyrite mixture) shall be added in five increments of 0.050 grams, followed by three increments of 0.250 grams. The balance of the contaminant may be added in larger increments at the discretion of the test conductor and NASA operations director.

Record the quantity of contaminant added. Maintain the flow rate at the nominal value as required. Record data.

(2) Simultaneously, with each addition of contamination, sample the water through the sample port downstream of the filter test specimen and perform a particle count according to the requirements of paragraph a.3.

NOTE: The results of step d.2 must be approved by the NASA operations director prior to performance of step d.3.

(3) Add the next recommended increment of contamination and repeat step d.2. Record the quantity of contamination added. If required, re-establish the flowrate to the nominal value (3 gpm). Record data.

(4) Repeat step d.3 until the maximum Delta P is reached or the Delta P is 50 psid.

(5) Approximately midway in the test, sample the propellant at the nominal flow rate for the filter (3 gpm) through the sample port upstream of the filter test specimen.

(6) Prior to termination of the test, re-establish the flow rate of the water to 3 gpm and sample the water through the sample port downstream of the filter test specimen and through the sample port upstream of the filter test specimen and perform a particle count according to the requirements of step a.3.

6.2 Deviations to the Basic Test Procedure

During testing of the first filter test specimen, Wintec P/N 15267-552 S/N 017, the 10 gpm flow rate required by step a.2 was unobtainable. A flow rate of 8 gpm was utilized for this portion of the tests. The second deviation occurred during the contamination susceptibility test

and consisted of the deletion of the requirement to count the iron pyrite particles in the 10 to 25-micron range. Both of these deviations are permanant for the remainder of the tests to be conducted under TD-121-FTP-003, Revision B.

7.0 TEST FACILITY

7.1 Test Site

The test fixture used for the conduct of the tests is housed in a sheet metal, polyethylene-roofed shelter under test stand 302. Figure 2 is a photograph of the shelter designed to protect the test fixture from adverse environmental factors such as wind, rain, and snow.

7.2 Test Fixture

A flow schematic of the test fixture is shown in figure 3. In reality the test fixture consists of two basic units. Unit OTV-001, the pump unit, consists primarily of the fluid pump, propellant (water) tank, heat exchanger, and pressurization system. Figure 4 is a photograph of the OTV-001 unit. A portion of the shelter heating duct is also shown in the photograph. Unit OTV-002 is the flow unit consisting of the fluid clean-up filters, contamination addition system, instrumentation to measure flow and pressures, and the sampling/in-place particle counting system. Figure 5 is a photograph of the front of the OTV-002 unit. The sampling/in-place particle counting section of the unit is shown on the left side of the photograph. Figure 6 is a view of the rear of the OTV-002 unit showing the fluid membrane clean-up filters and the contamination addition system, as well as the test specimen location.

In general, the all stainless steel system consists of various welded sub-assemblies flanged together using Florogreen or metal gaskets.

7.2.1 Sampling/in-place particle counting system

The sampling/in-place particle counting system consists of two principal parts, the sampling wedge located in the flow system and the in-place particle counting system located in a class 100 laminar flow bench in front of the flow unit. In order to obtain a good representative sample of the fluid in the system, two Wyle wedge type samplers S-1 and S-2 are included in the flow system (refer to figure 3). Sampler S-1 is located upstream of the 1.5-micron membrane clean-up filters, F-2 and F-3, and the contamination addition system (refer to figure 3). Sampler S-2 is located downstream of the filter test specimen as shown in the lower right of figure 6. Figure 7 is an illustration of a typical Wyle wedge sampler. The wedge type sampler was selected to provide a cross-section of the flow through the flow system and thus overcome any problems due to the combination of low flow rate and the density of the particulate contamination. Sampler S-1, located upstream of the test specimen, is not connected to the in-place particulate counting system used for samples obtained through sampler S-2, located

downstream of the filter test specimen. Samples obtained from sampler S-1 are not required to meet strict cleanliness requirements since the samples are obtained only to indicate the general contamination characteristics of the fluid in the system upstream of the membrane clean-up filters. Figure 8 is a photograph taken during the in-place counting of a sample. Figure 9 is a photograph of the in-place sample counting system which is further characterized by the flow schematics shown in figure 10. Figure 9 shows a Wintec sampler installed in the in-place counting system.

Flow from the wedge sampler is controlled by operation of the 3-way Whitey valve (V-31). Using this system, the membrane filter pad in the Wintec sampler is dried with filtered GN_2 emitted through the Whitey 3-way valve. Use of the in-place counting system eliminates problems due to handling of the Wintec sampler and provides for the elimination of connection contamination through the use of a background "blank" count obtained after installation of the Wintec sampler.

7.2.2 Contamination addition system

Figure 11 illustrates the configuration of a contamination addition tube. Each tube consists of a valve and tube assembly into which measured amounts of contamination are induced with valve number 2 closed (contamination rests on top of the valve). The contamination addition tubes are prepared in the laboratory as a sub-assembly of five units. The arrangement of the contamination addition system is such that fluid flow can be directed individually through any one of the five tubes. Figure 6 shows, in the center, a set of five tubes installed in the OTV-002 unit.

7.2.3 Operational characteristics of the test fixture

7.2.3.1 Flow path

The principal fluid flow path through the test fixture, excluding the contamination addition versus Delta P portion of the test, passes all of the fluid through the 1.5-micron membrane clean-up filters F-2 and F-3 (refer to figure 3). During the contamination addition (susceptibility) test 1.5 gpm of the 3.0 gpm total flow is directed through the contamination addition system to add contamination to the upstream side of the filter test specimen. Preliminary engineering tests indicated that six to ten seconds are required to move the contaminant from the contamination addition system to the test specimen location as observed by samples obtained through sampler S-2 (refer to figure 3).

During contamination addition tests the sampling valve V-31 (refer to figure 10) is opened four seconds after contamination is released from the contamination addition system. Approximately fifty seconds are required to collect a 500 ml sample.

7.2.4 Test system qualification tests

In addition to the engineering tests conducted to determine the contaminant addition time, two system clean-up tests were conducted to verify test readiness.

7.2.4.1 Pre-test series system clean-up tests

Prior to the initiation of the interface filter tests using water as the test fluid, a series of system cleanliness tests were conducted. Table I lists the results obtained on the eleven pre-test system cleanliness verification samples. No iron pyrite particles were observed in the samples greater than 10 microns. After completion of the eleven-sample test, the system was shut down, the "tare" test specimen removed and replaced, and flow re-initiated. After approximately 30 minutes, three additional samples were obtained from the flow system through V-31 to demonstrate that the actions associated with the installation of the test specimen do not contaminate the system with iron pyrites greater than 50 microns. Table II lists the results obtained on these samples.

7.2.4.2 System clean-up between tests

After completion of the first test on filter specimen Wintec P/N 15267-552 S/N 017, the fluid in the system was drained and the section of the system between the downstream side of the filter test specimen, including the wedge sampler (S-2), was removed and replaced with a new section sized for the second filter to be tested (Wintec P/N 15267-556 S/N 009).

Subsequently, the system was reloaded with deionized water and the membrane clean-up filters replaced with new media. The system was flowed for approximately eight hours and then sampled through the V-31 using the standard in-place counting method (appendix A contains the sampling/in-place counting procedure). Table III lists the particle count results obtained on the six pre-test system cleanliness verification samples. No iron pyrite particles were observed in the samples greater than 10 microns. These results indicated that the system was sufficiently clean to proceed with the second filter test.

8.0 TEST RESULTS

The results of the tests covered by this report are divided into two parts, the results on each filter test specimen being presented separately.

8.1 Test Results Obtained on Filter Test Specimen Wintec P/N 15267-552 S/N 017

Table IV lists the particle count data obtained on samples acquired through the V-31 sampling port during the portion of the test procedure designed to demonstrate the cleanliness of the system. The procedure used to obtain and count the samples is described in appendix A. The samples were obtained from the system while it was flowing at 3 gpm and at a pressure of 10 psig at the sampler wedge (S-2). The data reports the absence of iron pyrite particles in the system. The non-iron pyrite particulate observed during these and subsequent samples consisted mainly of teflon particles.

Figure 12 illustrates the test specimen "tare" Delta P versus flow rate (gpm) as compiled from the test data listed in Table V. Figure 13 illustrates the test specimen fluid outlet temperature and test specimen inlet fluid pressure during the measurement of test specimen "tare" Delta P and flow rate. Table VI lists the system cleanliness conformation particle count data obtained on samples acquired through the V-31 sampling port prior to installation of the test specimen and after determination of "tare" Delta P versus flow rate data.

Figure 14 shows the test specimen "net" Delta P versus flow rate (gpm) obtained using "clean" deionized water. The "net" Delta P values were obtained by subtracting the appropriate flow rate "tare" Delta P from the "gross" Delta P measured during the test. The raw data and associated computations are shown in Table VII. Figure 15 illustrates the test specimen fluid outlet temperature and the test specimen inlet pressure during the measurement of test specimen "gross" Delta P versus flow rate.

Table VIII lists the particle count data obtained on samples acquired through the V-31 sampling port after installation of the test specimen to confirm system cleanliness. These samples were obtained prior to the addition of contamination and were obtained from the system while it was flowing at 3 gpm. The pressure at the sampler (S-2) was 10 psig. Table IX lists the particle count data obtained on 500 ml samples of the water passing through the test specimen during the

addition of the A.C. coarse dust/iron pyrite contaminant. The data indicates that the largest iron pyrite particle was observed during the fifth contaminant addition and was in the 50 to 75-micron size range. At this point, the Delta P across the filter had increased to approximately 2 psig. During this portion of the test, the flow rate was maintained at 3 gpm. Adjustment of system flow rate and pressure parameters were required as the Delta P across the filter increased.

The samples obtained using Millipore high pressure membrane samplers from V-17 indicated that approximately half of the three gpm flow to the upstream side of the filter test specimen during the contamination susceptibility test contained the following average particle count.

Size Range (Microns)	Average Particle Count per 500 ml
10 - 25	195
25 - 50	61
50 - 100	24
Greater than 100	15

The samples were obtained from V-17 following the procedure described in appendix B.

Figure 16 illustrates the "net" Delta P across the filter versus the quantity of A.C. coarse dust/iron pyrite mixture added to the upstream side of the filter. The figure is keyed to show the quantity of contaminant added. The flow rate through the filter was 3 gpm. Figure 17 shows the test specimen fluid outlet temperature and test specimen fluid inlet pressure during this portion of the test. The raw flow rate, temperature, and pressure data are listed in table X.

8.2 Test Results Obtained Filter Test Specimen Wintec P/N 15267-556 S/N 009

Table XI lists the particle count data obtained on samples acquired through the V-31 sampling port during the portion of the test procedures designed to demonstrate the cleanliness of the system. The samples were obtained from the system while flowing at 3 gpm and a pressure of 10 psig at the sampler wedge (S-2). The data reports the absence of iron pyrite particles greater than 50 microns in size. The non-iron pyrite particles consisted of teflon particles and slag or stainless steel particles. Figure 18 illustrates the test specimen "tare" Delta P versus flow rate (gpm) as compiled from the test data listed in table XII. Figure 19 illustrates the test specimen fluid outlet temperature and test specimen inlet fluid pressure during the measurement of test specimen "tare" Delta P and flow rate. Table XIII lists the system cleanliness conformation particle count data obtained on samples acquired through the V-31 sampling port prior to installation of the test specimen.

Figure 20 shows the test specimen "net" Delta P versus flowrate (gpm) obtained using "clean" deionized water. As noted in section 8.1, the "net" Delta P values were obtained by subtracting the appropriate flow rate "tare" Delta P from the "gross" Delta P measured during the test. The raw test data and associated computations are shown in table XIV. Figure 21 illustrates the test specimen fluid outlet temperature and the test specimen fluid inlet pressure during the measurement of test specimen "gross" Delta P versus flow rate. Table XV lists the particle count data obtained on samples acquired through the V-31 sampling port, after installation of the test specimen, to confirm system cleanliness. These samples were obtained prior to the addition of contamination and were obtained from the system while it was flowing at 3 gpm. The pressure at the sampler (S-2) was 10 psig. Table XVI lists the particle count data obtained on 500 ml samples of the water passing through the test specimen during the addition of the A.C. coarse dust/iron pyrite contaminant. The data indicates that the largest iron pyrite particle observed during the test was in the 25 to 50-micron size range and appeared during the eleventh contaminant addition. At this point the Delta P across the filter had increased to approximately 30 psig. During this portion of the test, the flow rate was maintained at 3 gpm. The system fluid pressure at the sampler (S-2) was maintained at 10 psig. Adjustment of the system flow rate and pressure parameters were required as the Delta P across the filter increased.

The samples obtained using Millipore high pressure membrane samplers from V-17 indicated that approximately half of the three-gpm flow to the upstream side of the filter test specimen during the contamination susceptibility test contained the following average particle count.

Size Range (Microns)	Average Particle Count per 500 ml
10 - 25	198
25 - 50	72
50 - 100	29
Greater than 100	6

Figure 22 illustrates the "net" Delta P across the filter versus the quantity of A.C. coarse dust/iron pyrite mixture added to the upstream side of the filter. The figure is keyed to show the quantity of contaminant added. The flow rate through the filter was 3 gpm.

Figure 23 shows the test specimen fluid outlet temperature and test specimen fluid inlet pressure during this portion of the test. The raw flow rate, temperature, and pressure data are listed in table XVII.

9.0 DISCUSSION OF TEST RESULTS

9.1 Particle Count Data

Examination of the particle count data listed in Tables IX and XVI, obtained on samples acquired during the contaminant addition test, clearly indicated that the particle count using iron pyrite as the identifiable contaminant met the following particle count requirements for both filters tested.

Size Range (Microns)	Particle Count per 500 ml (Maximum)
0 - 50	Unlimited
50 - 75	100
75 - 100	10
Greater than 100	0

Figures 24 and 25 are photographs of typical non-iron pyrite particles observed during the test. Subsequent tests on the Whitey 3-way valve (V-31) used in the sampling system and on an unused Whitey 3-way valve indicated that the valve was the source of most of the non-iron pyrite particles. Figure 26 was obtained on a particulate sample taken during laboratory tests on one Whitey 3-way valve and shows the same kind of particulate. Examination of the valve internal parts indicated the teflon-coated metal inserts to be the principal source of the particulate. Figure 27 is a photograph of the Whitey 3-way valve internal parts. The photograph shows only half of the teflon ball housing. Figure 28 is a photograph of the surface of one of the metal inserts showing a close-up of the loose teflon coating.

A review of the particle count data listed in tables I, III, IV, VIII, IX, XI, XIII, XV, and XVI shows that negative particle counts are occasionally encountered using the method of in-place counting. The negative counts are probably due to a combination of the inherent manual particle counting error, frequently reported to be approximately 20%, and the fact that particles can collect on surfaces within the Wintec sampler which are not countable. The Wintec sampler, shown installed in the in-place counting system under the microscope in figure 9, is constructed with an internal ledge which is not counted. Particle matter often adheres to the underside of the glass cover and is normally not counted. Figure 29 is a photograph of the ledge or shelf in the Wintec sampler taken through a microscope indicating the rough surface character which prohibits particle counting due to light reflections. Figure 30 is a photograph taken through a microscope of the underside of the glass cover showing numerous small (25-60 microns) particles adhering to the surface. Figure 31 is a photograph, taken

through a microscope, of a large (365 microns) teflon particle adhering to the vertical surface of the ledge. The vertical and flat surfaces of the ledge and the underside of the glass were occasionally scanned for particulate. Occasionally iron pyrite particles were observed that were less than 50 microns in size. In spite of these shortcomings, the Wintec sampler does permit a significant advancement over the normal particle counting procedure where the membrane filter pad is removed from the sampler, risking exposure to contamination, and counted in an open "clean" environment.

9.2 Flow Rate - Delta P Data

Figures 14 and 20 indicate the change in test specimen Delta P as a function of flow rate using "clean" deionized water as the test fluid. The data is presented for the flow rate range which could be encountered during use of the filters. Similar data was not presented in Wintec Corporation report number TR-161 covering tests on the Wintec filters. Figure 20 reports a non-smooth change in Delta P as a function of flowrate which will be confined by the oxidizer test.

Figures 16 and 22 illustrate the increase in Delta P as a function of the amount of A.C. course dust/iron pyrite contaminant added upstream of the test specimen. The trend of the data obtained on the two test specimens compares favorably with the data obtained by the Wintec Corporation during tests on test specimen P/N 15267-552 S/N 006 using deionized water as the test fluid and A.C. course dust as the contaminant. Figure 32 was prepared from data in Wintec Corporation report number TR-161 and shows the "net" test specimen Delta P versus quantity of A.C. course dust added upstream of the test specimen. The data was obtained during Wintec Corporation tests on P/N 15267-552 S/N 006.

The variation in "net" Delta P values observed in the WSTF test data shown in figures 16 and 22 may be attributed to a combination of how the Delta P was observed to increase and the time that the data was recorded. During tests on the second test specimen, P/N 15267-556 S/N 009, data was recorded over a long period prior to the next addition of contamination for three additions of contamination. Figure 33 is a plot of the "gross" Delta P observed during the first, third, and sixth contaminant additions. The figure clearly indicates that, if the data were recorded too soon after a contaminant addition or at a variable time interval, data would be obtained that would not reflect the true stable Delta P. The manner in which the Delta P builds up and stabilizes may be due to a rearrangement of the contamination with time. It should be noted that iron pyrite is about twice as dense as the silicates (A.C. course dust). The variation in the time required to

reach a stable Delta P was only experienced during the initial contamination additions. Figures 34 and 35 illustrate the typical changes experienced during the addition of contamination on Delta P and flow rate. Figure 34 is a plot of the changes experienced during the sixth contaminant addition during which 0.25 grams were added to the 0.25 grams previously added. The high peak values observed in the Delta P curve represent the opening of the contamination addition loop at Time zero and the closing of the loop approximately 60 seconds later. Figure 35 illustrates the typical changes experienced during the eleventh contaminant addition when the Delta P across the test specimen was considerably higher (approximately 18 psid). At this point in the test 0.75 grams of contaminant were being added to 2.25 grams already added. At this Delta P level, a noticeable change in the flow rate was observed accompanied by a very quickly acquired stable Delta P. The data reported in figures 34 and 35 were obtained during tests on test specimen Wintec P/N 15267-556 S/N 009.

10.0 CONCLUSIONS AND RECOMMENDATIONS

The flow rate/Delta P data obtained during the tests was comparable to data obtained by Wintec Corporation as reported in Wintec report number TR-161. A satisfactory WSTF data baseline for tests conducted with water as the test fluid was obtained for comparison with data to be obtained during tests on the same filter part numbers using live propellants as the test fluid. In addition, the filter test specimens satisfactorily demonstrated compliance with the requirement for the maximum amount of particulate passed. The particulate requirement is as follows:

Size Range (Microns)	Particle Count per 500 ml (Maximum)
0 - 50	Unlimited
50 - 75	100
75 - 100	10
Greater than 100	0

A uniform time, before data readings are obtained following contaminant addition, should be used in future tests to insure stable Delta P data. The use of a non-particulate generating sample valve or a valve that generates only identifiable contaminant could be used in future tests to provide simpler particle counts. An additional improvement to the sampling/in-place counting system would be the use of a sampler that has a minimum of surfaces not routinely counted for particulate. Such a sampler would not have the ledge as in the Wintec sampler.

APPENDIX A

GENERAL SAMPLING/IN-PLACE COUNTING PROCEDURE

GENERAL SAMPLING/IN-PLACE COUNTING PROCEDURE

Sampling Procedure at V-31 Using the Wintec Sampler
(Refer to figure 9)

NOTE: (1) The Wintec samplers are prepared for use in the sampling/in-place counting system following laboratory job instruction 3006, appendix F-1, issued January 9, 1969. (A copy of the detailed laboratory job instruction is given in appendix B.)

(2) The first sample taken on a newly installed Wintec sampler is a background "blank" and is not to be counted as a sample.

1. With care, remove the Wintec sampler from its bag.

2. Slide B-nut back to the case.

3. Carefully connect the Wintec sampler to the union in the line from V-31.

4. Verify V-52 is in the open position and GN_2 purge pressure is set at 15 $\pm$ 1 psig.

5. Place the vent line hose into the graduated beaker.

6. Place V-31 to the sample position and flow 500 ml of sample fluid through the sampler.

7. Place V-31 to the purge position.

8. When the water is forced out of the Wintec sampler, adjust the GN_2 purge pressure to 10 $\pm$ 1 psig. Continue purge until sampler is dry.

9. Place V-31 to the off position.

10. Perform an in-place particle count of iron pyrite particles in the following size ranges:

a. 10-25μ

b. 25-50μ

c. 50-75μ

d. 75-100μ

e. Greater than 100μ

11. Perform an in-place particle count of all other particles in the following size ranges:

a. 50-100μ

b. Greater than 100μ

12. List the largest size particle of any material other than iron pyrites and the largest fiber.

13. Record time, sample location and particle count data.

NOTE: Step 10 was deviated during the conduct of the test to eliminate the 10-25μ size range particle count.

Sampling Procedure at V-17 Using Millipore High Pressure Sampler

1. Open V-17 and flow approximately 2000 ml of fluid through the valve; discord fluid.

2. Remove caps from the Millipore high pressure sampler in the laminar flow bench and carefully connect the Millipore sampler to V-17.

3. Connect a piece of tygon tubing to the exit side of the Millipore sampler and place the end of the tribing in a graduated beaker.

4. Open V-17 and flow 500 ml of the sample fluid through the sampler; close V-17.

5. Carefully disconnect the sampler and install the caps.
CAUTION: Keep the sampler vertical at all times.

6. Submit the Millipore high pressure sampler to the laboratory for a particle count in the following size ranges:

a. 10-25μ

b. 25-50μ

c. 50-100μ

d. Greater than 100μ

APPENDIX B

PROCEDURE FOR PREPARATION

OF

WINTEC SAMPLERS

LJI 3006, Appendix F-1

SUBJECT: Cleaning and Assembly of Wintec Membrane Filter Samplers

1. GENERAL INFORMATION:

   a. This instruction covers all phases of cleaning and assembling of Wintec Samplers. It specifically pertains to preparation of Wintec samplers for the Filter Test Program, but is applicable to Wintec samplers used for other purposes. This procedure may be cited for cleaning of other parts for the Filter Test Program.

2. REFERENCES:

   a. MSC Form 127 (Rev. Feb.67) Work Request and Contamination Control Laboratory Report.

   b. See Page One of this Manual.

3. SAFETY PRECAUTIONS:

   a. Observe normal safety precautions during this operation as described in Contamination Control Procedures.

4. INSTRUCTIONS:

   a. Precleaning

      (1) Submit the Wintec sampler for cleaning on MSC Form 127 (Rev. Feb. '67). The parts of the assembly shall be top section, base, screen, and two screws. Cite this procedure in the block marked "spec. and level".

      (2) Degrease assembly parts in Freon.

      (3) Clean in Oakite 26 or 33 for two to three minutes using ultrasonic action.

      (4) Rinse the parts thoroughly in deionized water.

      (5) Repeat steps (3) and (4) a total of five times.

      (6) Rinse in hot water (minimum temperature 120^{o}F) using ultrasonic action for two to three minutes.

      (7) Rinse the parts in deionized water.

(8) Repeat steps (6) and (7) a total of five times.

(9) Rinse the parts with alcohol to remove water.

(10) Dry the parts with GN_2.

b. Precision cleaning

CAUTION

EXERCISE EXTREME CARE WITH HANDS AND BODY IN RELATION TO THE CLEAN PARTS CONSISTENT WITH DOWNFLOW CLEAN ROOM TECHNIQUES. DIRECT SPRAY RINSE UP INTO PART. WORK AT ARMS LENGTH WHENEVER POSSIBLE.

NOTE

STEPS b(3) THROUGH b(12) NEED BE PERFORMED ONLY AT THE BEGINNING OF EACH 8 HOUR SHIFT OR WHEN DIRECTED BY QA.

(1) Rinse the parts for two to three minutes in deionized water using ultrasonic action. Use the left hand side of the Bendix Filter Cleaner Unit for this operation.

(2) Drain and refill the tank. Rinse the parts a total of five times with ultrasonic action changing the water between rinses.

(3) Place a clean filter AABG membrane (.8 microns)in Millipore #61.

(4) Lock Millipore #61 in a horizontal position so that the water stream goes into the clean side of the Branson Unit.

(5) Change the 293 mm filter.

(6) Start water flowing through Millipore #61.

(7) Sample (250 ml) the Bendix 2 Unit spray lance. Verify that the Freon meets the following particle count limits:

10 - 25 microns	maximum 5
25 - 50 microns	maximum 2
over 50 microns	0

If the Bendix #2 Unit does not meet this sample requirement, a DR shall be written to resolve the Freon supply requirement.

(8) Sample (250 ml) the water from the filter jet on the pressurized water container: the particle count shall not exceed the following limits:

10 - 25 microns	maximum 5
25 - 50 microns	maximum 2
over 50 microns	none

NOTE
IF THE WATER CLEANLINESS DOES NOT MEET THIS REQUIREMENT A DR SHALL BE WRITTEN ON THE PRESSURIZED WATER SUPPLY TO RESOLVE THE WATER SUPPLY REQUIREMENT.

(9) Rinse an AABG membrane filter with Freon from the Bendix #2. Place the filter in a funnel assembly.

(10) Vigorously rinse the funnel assembly with Freon from Bendix Unit #2 and allow to dry.

(11) Vigorously rinse the funnel with water from the filter jet. Hold the funnel upside down at arms length and rinse with the filter jet approximately 2 feet away. Rinse the lip and outside as well as the inside of the funnel and the filter surface.

(12). Take a 250 ml grab sample from the Millipore #61 and filter the water through the filter funnel.

Place the membrane on a clean glass slide and count the damp membrane filter.

The particle count shall not exceed the following limits:

10 - 25 microns	maximum 5
25 - 50 microns	maximum 2
over 50 microns	0

NOTE
IF THE CLEANLINESS DOES NOT MEET THIS REQUIREMENT A DR SHALL BE WRITTEN ON THE BRANSON UNIT TO RESOLVE THE WATER SUPPLY REQUIREMENT. STEP 3 SHALL BE PERFORMED ONE TIME PRIOR TO ASSEMBLING A SERIES OF WINTEC SAMPLERS AND ADDITIONALLY WHEN DIRECTED BY QA.

(13) Rinse the Wintec parts with clean water from the Millipore outlet on the Branson Unit spray wand.

(14) Attach the top section of the Wintec assembly to the millipore filter on the Branson Unit and flow clean water through the top section of the holder for at least two minutes.

NOTE

THE ORIENTATION OF THE TOP SECTION OF THE WINTEC ASSEMBLY SHALL BE SUCH THAT THE SIGNIFICANT SURFACE OF THE GLASS IS FACING DOWNWARD.

(15) Obtain a 250 ml sample of water as it comes flushing from the Wintec top section. Filter the water and count the number of particles in the following ranges:

10 - 25 microns	maximum 8 allowed
25 - 50 microns	maximum 4 allowed
over 50 microns	0 allowed

Continue to flush and sample the top section until the particle count meets this requirement.

c. Assembly of Wintec Samplers

(1) Wash a membrane filter, of the type specified in the TPS, with clean water from the filter jet for a minimum of 30 seconds; hold the membrane filter on a clean glass slide using a cleaned pair of forceps and direct the spray onto the membrane filter from a distance of approximately two feet. Move the spray force over the entire filter membrane surface.

(2) With the membrane filter still on the glass slide scan the membrane under the microscope for particles greater than 50 microns. Rewash or throw away any membranes with a count greater than eight particles between 10 - 25 microns, four particles between 25 - 50 microns, and 0 particles greater than 50 microns.

(3) Place the Wintec base plate on the edge of the Branson Unit. Rinse the Wintec base plate with water from filter jet. Rinse the filter membrane briefly and then place it on the support screen.

(4) Hold the Wintec top section in one hand with the significant surface of the glass facing downward. With the filter jet in the other hand rinse the filter on the base plate. (If the force of the spray does not come straight down, the filter will slide off the base plate.) Rinse the critical surfaces of the Wintec top section from below with the filter jet. Rinse the filter again and then place the top section on the base plate. Be sure the top section is seated flat against the base plate and not cocked.

(5) Gently press the top firmly against the filter.

(6) Turn the Wintec assembly upside down and secure the base to the top with the two screws. Torque the screws to 12 in lbs. (+0,-2).

CAUTION
HANDLE THE ASSEMBLY GENTLY AND AVOID KNOCKING IT AGAINST ANYTHING.

(7) Dry the Wintec filter assembly by placing it under a heat lamp and pulling a vacuum on the outlet side of the holder.

(8) Count and record on data sheet the particles on the membrane inside the assembly. The particle count shall not exceed the following limits:

10 - 25 microns	8 maximum
25 - 50 microns	4 maximum
over 50 microns	0

If the assembly does not meet this requirement, disassemble the Wintec and repeat steps c(1) through c(8).

(9) Rinse the inside of a clean antistatic bag with previously certified Freon from Bendix #2, and allow to air dry. Seal the Wintec inside the bag so that the inlet of the Wintec is oriented in one corner of the bag.

(10) Place a rubber band around the bag so that it restrains the B nuts from any movement.

(11) Place the packaged Wintec into a polyethylene bag and seal.

TABLE I

PRETEST SYSTEM CLEANLINESS VERIFICATION SAMPLE RESULTS

Sampler Number	FeS_2 Size Range (Microns)					OTHER PARTICULATE Nonmetal Size Range (Microns)			OTHER PARTICULATE Metal Size Range (Microns)		
	10-25	25-50	50-75	75-100	>100	50-75	75-100	>100	50-75	75-100	>100
A	0	0	0	0	0	2	2	14	0	0	0
B	0	0	0	0	0	2	-1	-3	0	0	0
C	0	0	0	0	0	1	2	9	0	0	0
D	0	0	0	0	0	1	0	8	0	0	0
E	0	0	0	0	0	2	3	12	0	0	0
F	0	0	0	0	0	0	3	17	0	0	0
G	0	0	0	0	0	2	3	29	0	0	0
H	0	0	0	0	0	0	2	9	0	0	0
I	0	0	0	0	0	7	1	9	0	0	0
J	0	0	0	0	0	-3	2	7	0	0	0
K	0	0	0	0	0	10	4	26	0	0	0

TABLE II

PRETEST SYSTEM CLEANLINESS VERIFICATION SAMPLE RESULTS AFTER REPLACEMENT OF THE "TARE" PIECE

	FeS_2					OTHER PARTICULATE					
						Nonmetal			Metal		
	Size Range (Microns)					Size Range (Microns)			Size Range (Microns)		
Sample Number	10-25	25-50	50-75	75-100	>100	50-75	75-100	>100	50-75	75-100	>100
L	0	0	0	0	0	2	1	7	0	0	1
M	0	0	0	0	0	1	0	9	0	0	0
N	0	0	0	0	0	0	3	2	5	0	1

TABLE III

BETWEEN TESTS SYSTEM CLEANLINESS VERIFICATION RESULTS

Sample Number	FeS_2 Size Range (Microns)					Other Particulate: Nonmetal Size Range (Microns)			Other Particulate: Metal Size Range (Microns)		
	10-25	25-50	50-75	75-100	>100	50-75	75-100	>100	50-75	75-100	>100
A	0	0	0	0	0	2	2	1	1	0	0
B	0	0	0	0	0	0	1	0	1	0	0
C	0	0	0	0	0	4	-2	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	2	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0	0

TABLE V

Test Specimen P/N 15267-552 S/N 017 Tabulation of "Tare" Delta P Versus Flowrate Test Data

Flowrate (GPM)	Delta P (PSID)
0.98	0.0607
1.98	0.1928
3.01	0.4012
4.00	0.6738
4.97	1.0101

TABLE XI

TEST SPECIMEN (P/N 15267-556 S/N 009) DEMONSTRATION OF SYSTEM CLEANLINESS

Sample Number	FeS_2 Size Range (Microns) 25-50	50-75	75-100	>100	Other Particulate Nonmetal Size Range (Microns) 50-100	>100	Metal 50-100	>100	Largest Particle (Microns)	Longest Fiber (Microns)	
F-200	2	0	0	0	4	0	0	0	75	None	
F-201	1	0	0	0	5	0	1*	0	75S	None	*Slag
F-202	1	0	0	0	-3	0	-1	0	75S	None	
F-203	-3	0	0	0	1	0	1*	0	90	None	*Slag
F-204	2	0	0	0	-2	0	0	0	90S	None	
F-205	-1	0	0	0	-3	0	0	0	120	None	
F-206	1	0	0	0	3	0	-1	0	120S	None	
F-207	1	0	0	0	1	1	0	0	300	None	
F-208	0	0	0	0	0	0	1*	0	300S	None	*Stainless Stee
F-209	0	0	0	0	0	0	0	0	300S	None	
F-210	0	0	0	0	1	1	0	0	300S	None	

KEY: T - Appeared in tare
S - Appeared in previous sample

TABLE XII

Test Specimen (P/N 15267-556 S/N 009) Tabulation of "Tare" Delta P Versus Flowrate (GPM) Data

Flowrate (GPM)	"Tare" Delta P (PSID)
1.01	0.022
3.00	0.149
4.99	0.391
5.98	0.561
8.02	0.983

TABLE XIII

Test Specimen (P/N 15267-556 S/N 009)

DEMONSTRATION OF SYSTEM CLEANLINESS TEST RESULTS
OBTAINED PRIOR TO THE INSTALLATION OF THE TEST SPECIMEN

Sample Number	FeS_2 Size Range (Microns)				Other Particulate: Nonmetal Size Range (Microns)		Other Particulate: Metal Size Range (Microns)		Largest Particle (Microns)	Longest Fiber (Microns)	
	25-50	50-75	75-100	>100	50-100	>100	50-100	>100			
F-211	0	0	0	0	0	0	2*	0	300T	None	*Slag
F-212	0	0	0	0	2	0	-1	0	300S	None	
F-213	0	0	0	0	1	0	0	0	720	None	

KEY: T - Appeared in tare sample
S - Appeared in previous sample

TABLE XIV

Test Specimen (P/N 15267-556 S/N 009) Tabulation of "Net" Delta P Versus Flowrate (GPM) Test Data

Flowrate (GPM)	"Gross" Delta P (PSID)	"Tare" Delta P (PSID)	"Net" Delta P (PSID)
0.99	0.077	0.21	0.056
3.01	0.192	0.075	0.117
4.98	0.947	0.390	0.557
5.96	1.804	0.555	1.249
8.04	2.424	0.984	1.440

TABLE XV

TEST SPECIMEN (P/N 15267-556 S/N 009) CONFORMATION OF SYSTEM CLEANLINESS AFTER INSTALLATION OF TEST SPECIMEN

Sample Number	FeS_2 Size Range (Microns)				Other Particulate Nonmetal Size Range (Microns)		Other Particulate Metal Size Range (Microns)		Largest Particle (Microns)	Longest Fiber (Microns)
	25-50	50-75	75-100	>100	50-100	>100	50-100	>100		
F-216	0	0	0	0	0	-1	0	0	125T	None
F-217	0	0	0	0	1	0	0	0	125T	None
F-218	0	0	0	0	0	0	1	0	100	None

KEY: T - Appeared in tare sample
S - Appeared in previous sample

TABLE VII

Test Specimen P/N 15267-552 S/N 017 Tabulation of "Net" Delta P Versus Flowrate Test Data

Flowrate (GPM)	"Gross" Delta P (PSID)	"Tare" Delta P (PSID)	"Net" Delta P (PSID)
1.01	0.1613	0.0605	0.1008
2.02	0.4081	0.2000	0.2081
2.98	0.7568	0.3930	0.3638
4.02	1.2270	0.6800	0.5470
4.95	1.7460	0.9950	0.7510

TABLE IV

Test Specimen (P/N 15267-552 S/N 017)

DEMONSTRATION OF SYSTEM CLEANLINESS TEST RESULTS

Sample Number	FeS_2 Size Range (Microns) 10-25	25-50	50-75	75-100	>100	OTHER PARTICULATE: Nonmetal Size Range (Microns) 50-75	75-100	>100	Metal Size Range (Microns) 50-75	75-100	>100	Largest Particle (Microns)	Longest Fiber (Microns)	
F-100	0	0	0	0	0	0	2	4	0	1*	0	150T	400	*Slag
F-101	0	0	0	0	0	0	2	13	0	0	0	150T	1200	
F-103	0	0	0	0	0	2	1	2	0	0	0	360T	--	
F-104	0	0	0	0	0	1	0	2	0	0	0	360T		
F-105	0	0	0	0	0	1	1	11	0	0	0	1020	None	
F-107	0	0	0	0	0	4	3	6	0	0	0	440T	325T	
F-108	0	0	0	0	0	2	0	6	0	0	0	440T	325T	
F-109	0	0	0	0	0	2	1	5	0	0	0	2500	325T	
F-110	0	0	0	0	0	1	5	11	0	0	0	2500S	325T	
F-112	0	0	0	0	0	1	2	4	0	0	2*	550	None	*125 and 185 Microns
F-113	0	0	0	0	0	4	1	3	0	0	0	550S	None	

KEY: T - Appeared in tare sample
S - Appeared in previous sample

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TABLE VI

Test Specimen (P/N 15267-552 S/N 017)

DEMONSTRATION OF SYSTEM CLEANLINESS TEST RESULTS OBTAINED PRIOR TO THE INSTALLATION OF THE TEST SPECIMEN

Sample Number	FeS_2 Size Range (Microns)					OTHER PARTICULATE: Nonmetal Size Range (Microns)			OTHER PARTICULATE: Metal Size Range (Microns)			Largest Particle (Microns)	Longest Fiber (Microns)	
	10-25	25-50	50-75	75-100	>100	50-75	75-100	>100	50-75	75-100	>100			
F-115	0	0	0	0	0	0	2	10	0	0	0	1230	165	
F-116	0	0	0	0	0	3	6	9	0	1*	0	240	1150	*Slag
F-117	0	0	0	0	0	7	0	12	0	0	0	240S	1150S	

KEY: T - Appeared in tare sample
S - Appeared in previous sample

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TABLE VIII

Test Specimen (P/N 15267-552 S/N 017)

CONFORMATION OF SYSTEM CLEANLINESS AFTER INSTALLATION OF TEST SPECIMEN

Sample Number	FeS_2 Size Range (Microns) 10-25	25-50	50-75	75-100	>100	OTHER PARTICULATE: Nonmetal Size Range (Microns) 50-75	75-100	>100	Metal Size Range (Microns) 50-75	75-100	>100	Largest Particle (Microns)	Longest Fiber (Microns)
F-122	0	0	0	0	0	1	-2	-9	0	0	0	--	--
F-123	0	0	0	0	0	0	0	11	0	0	0	--	360
F-124	0	0	0	0	0	4	3	8	0	0	0	120	360S

KEY: T - Appeared in tare sample
S - Appeared in previous sample

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TABLE IX

Test Specimen (P/N 15267-552 S/N 017)

TABULATION OF PARTICLE COUNT DATA ACQUIRED DURING THE CONTAMINATION ADDITION TEST

Sample Number	Contaminant Addition Number	Contaminant Added Grams	FeS_2 Size Range (Microns) 10-25	25-50	50-75	75-100	>100	OTHER PARTICULATE Nonmetal Size Range (Microns) 50-75	75-100	>100	Metal Size Range (Microns) 50-75	75-100	>100	Largest Particle (Microns)	Longest Particle (Microns)	
F-125	1	0.05	6	3	0	0	0	1	0	6	0	0	0	250	600	
F-126	2	0.05	3	1	0	0	0	1	6	9	0	0	0	250S	600S	
F-128	3	0.05	1	1	0	0	0	1	5	3	0	0	0	140T	480T	
F-129	4	0.05	2	0	0	0	0	1	0	8	0	0	0	140T	480T	
F-131	-	-	2	0	0	0	0	1	0	8	0	0	0	1150T	None	No Contaminant Added
F-132	5	0.25	-1	1	1	0	0	2	1	8	0	0	0	1150T	None	
F-134	6	0.25	1	3	0	0	0	1	3	-7	0	0	0	1030T	None	
F-135	7	0.25	0	-3	0	0	0	-1	2	7	0	0	1*	1030T	None	*True metal particle
F-137	8	0.75	9	0	0	0	0	2	0	6	3*	1*	0	720	None	*Slag
F-139	9	0.75	23	2	0	0	0	0	1	6	0	0	-1	720S	None	
F-141	10	1.00	NC	3	0	0	0	0	3	10	0	0	0	360	None	
F-142	11	1.00	NC	6	0	0	0	-2	2	3	0	1*	0	360S	None	*Slag
F-143	12	1.00	NC	5	0	0	0	3	-1	7	1*	0	0	360S	None	*Slag
F-145	-	-	NC	7	0	0	0	4	3	6	0	0	0	360S	None	

KEY: NC - Not Counted
T - Appeared in Tare Sample
S - Appeared in Previous Sample

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TABLE X

Test Specimen P/N 15267-552 S/N 017

TABULATION OF TEST SPECIMEN DATA ACQUIRED DURING CONTAMINANT ADDITION TEST

Fluid Outlet Temperature (°F)	Fluid Inlet Pressure (PSIA)	Flowrate (GPM)	"Gross" Delta P (PSID)	"Tare" Delta P (PSID)	"Net" Delta P (PSID)	Contamination Addition Rate (Grams)	Accumulated Contamination Added (Grams)
80.02	22.88	3.06	0.8313	0.4130	0.4183	0.05	0.05
79.74	23.32	3.04	1.3541	0.4082	0.9459	0.05	0.10
80.40	22.91	3.05	0.9125	0.4120	0.5005	0.05	0.15
80.39	23.39	3.03	1.6171	0.4060	1.2111	0.05	0.20
78.21	22.98	3.04	1.1391	0.4082	0.7309	0.25	0.45
77.92	23.90	3.02	2.2031	0.4040	1.7991	0.25	0.70
77.75	25.53	2.99	4.0041	0.3970	3.6071	0.25	0.95
78.52	32.44	3.02	10.5730	0.4040	9.9790	0.75	1.70
79.55	38.33	3.04	15.8000	0.4082	15.3920	0.75	2.45
80.40	56.00	2.98	33.0470	0.3940	32.6530	1.00	3.45
80.53	67.61	2.98	44.5890	0.3940	44.1950	1.00	4.45
80.68	82.58	2.99	60.0000	0.3970	59.6030	1.00	5.45

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TABLE XVI

Test Specimen (P/N 15267-556 S/N 009)

TABULATION OF PARTICLE COUNT DATA ACQUIRED DURING THE CONTAMINATION ADDITION TEST

Sample Number	Contaminant Addition Number	Contaminant Added Grams	FeS_2 Size Range (Microns) 25-50	50-75	75-100	>100	OTHER CONTAMINANT Nonmetal Size Range (Microns) 50-100	>100	Metal Size Range (Microns) 50-100	>100	Largest Particle (Microns)	Longest Fiber (Microns)
F-219	1	0.05	0	0	0	0	0	0	0	0	100T	None
F-220	2	0.05	0	0	0	0	-1	0	-1	0	100S	None
F-222	3	0.05	0	0	0	0	1	0	0	0	100	None
F-223	4	0.05	0	0	0	0	0	1	0	0	460	None
F-224	5	0.05	0	0	0	0	0	1	0	0	460S	None
F-226	6	0.25	0	0	0	0	0	2	0	0	350	None
F-227	7	0.25	0	0	0	0	0	1	0	0	600	None
F-229	8	0.25	0	0	0	0	1	0	3*	1*	575	None *Slag or stainless steel
F-230	9	0.50	0	0	0	0	-1	1	0	0	575S	None
F-231	10	0.75	0	0	0	0	0	1	2	0	480	None
F-234	11	1.00	1	0	0	0	1	2	2*	0	175T	None *Slag or stainless steel
F-235	12	1.00	2	0	0	0	3	-1	1*	0	360	None *Slag or stainless steel
F-238	13	1.00	1	0	0	0	2	3	3*	0	330T	None *Slag
F-239	-	-	0	0	0	0	0	-1	0	0	360	None

KEY: T - Appeared in tare sample
S - Appeared in previous sample

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TABLE XVII

Test Specimen (P/N 15267-556 S/N 009)

TABULATION OF TEST SPECIMEN DATA ACQUIRED DURING THE CONTAMINATION ADDITION TEST

Flowrate (GPM)	Fluid Outlet Temperature (^oF)	Inlet Pressure (PSIA)	"Gross" Delta P (PSID)	"Tare" Delta P (PSID)	"Net" Delta P (PSID)	Contamination Added (Grams)	Total Contamination Added (Grams)
2.98	86.1	22.9	0.945	0.147	0.798	0.05	0.05
2.97	86.2	23.4	1.472	0.146	1.326	0.05	0.10
2.99	85.1	22.7	0.651	0.148	0.503	0.05	0.15
2.98	84.3	23.3	1.341	0.147	1.194	0.05	0.20
2.98	84.0	23.4	1.565	0.147	1.418	0.05	0.25
2.98	82.9	23.3	1.287	0.147	1.140	0.25	0.50
2.95	82.9	24.8	3.079	0.144	2.935	0.25	0.75
2.98	82.9	29.4	7.309	0.147	7.162	0.25	1.00
3.02	82.8	36.3	13.932	0.151	13.781	0.50	1.50
3.02	82.7	43.3	20.832	0.151	20.681	0.75	2.25
3.01	82.6	50.6	30.177	0.150	30.027	0.75	3.00
3.05	83.4	61.3	40.707	0.154	40.553	1.00	4.00
3.01	84.8	75.4	54.802	0.150	54.652	1.00	5.00

FOLDOUT FRAME

FOLDOUT FRAME

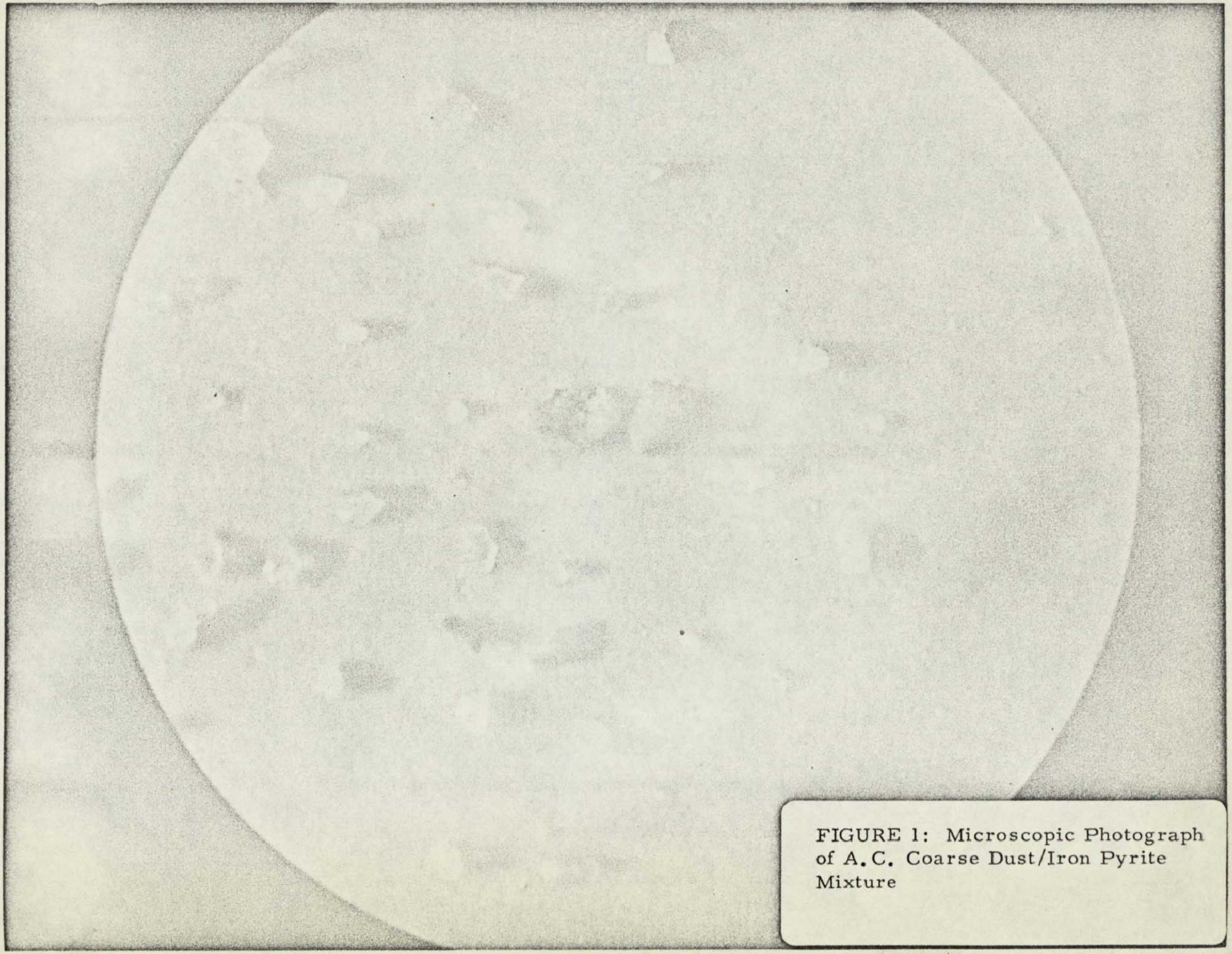


FIGURE 1: Microscopic Photograph of A.C. Coarse Dust/Iron Pyrite Mixture

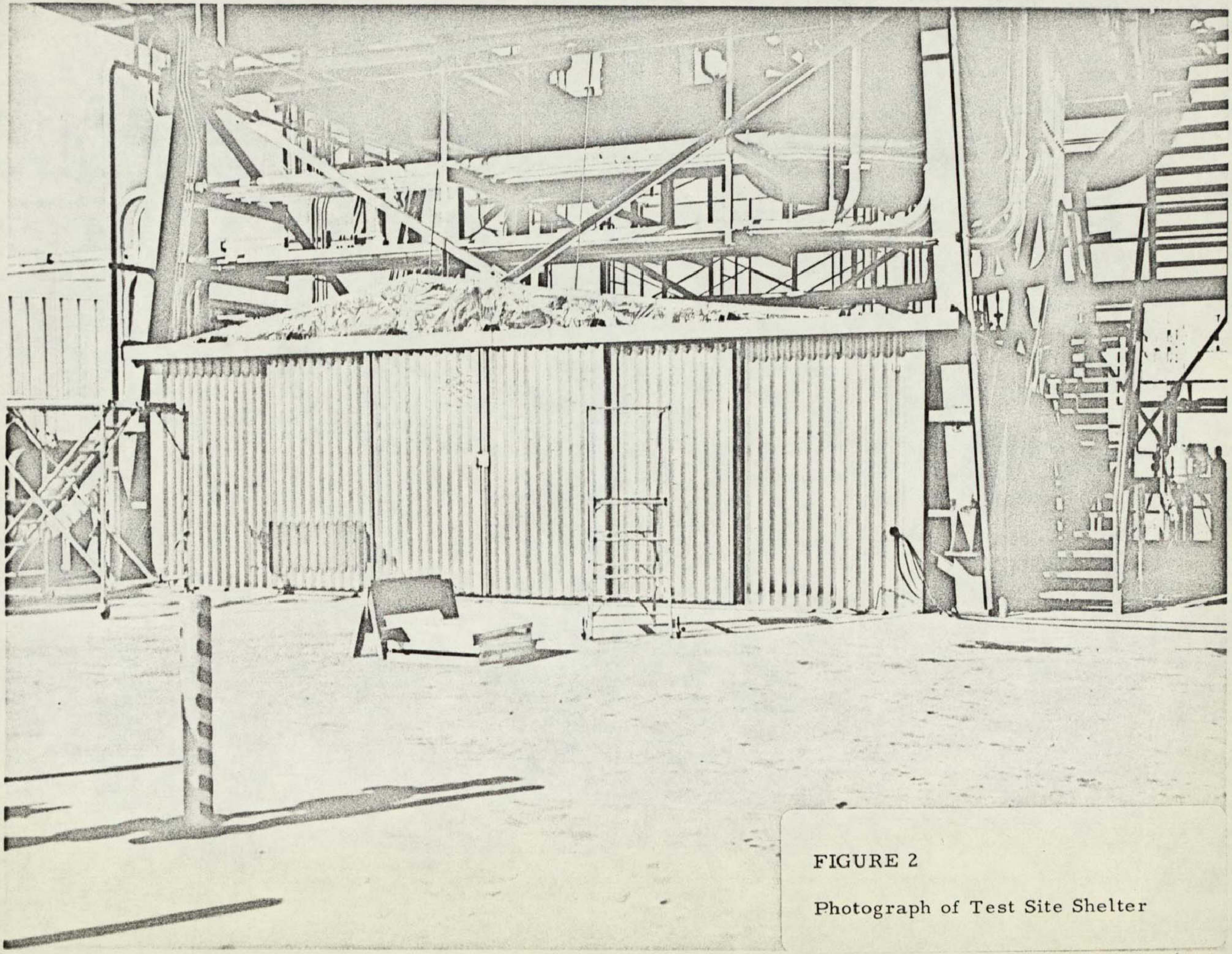


FIGURE 2

Photograph of Test Site Shelter

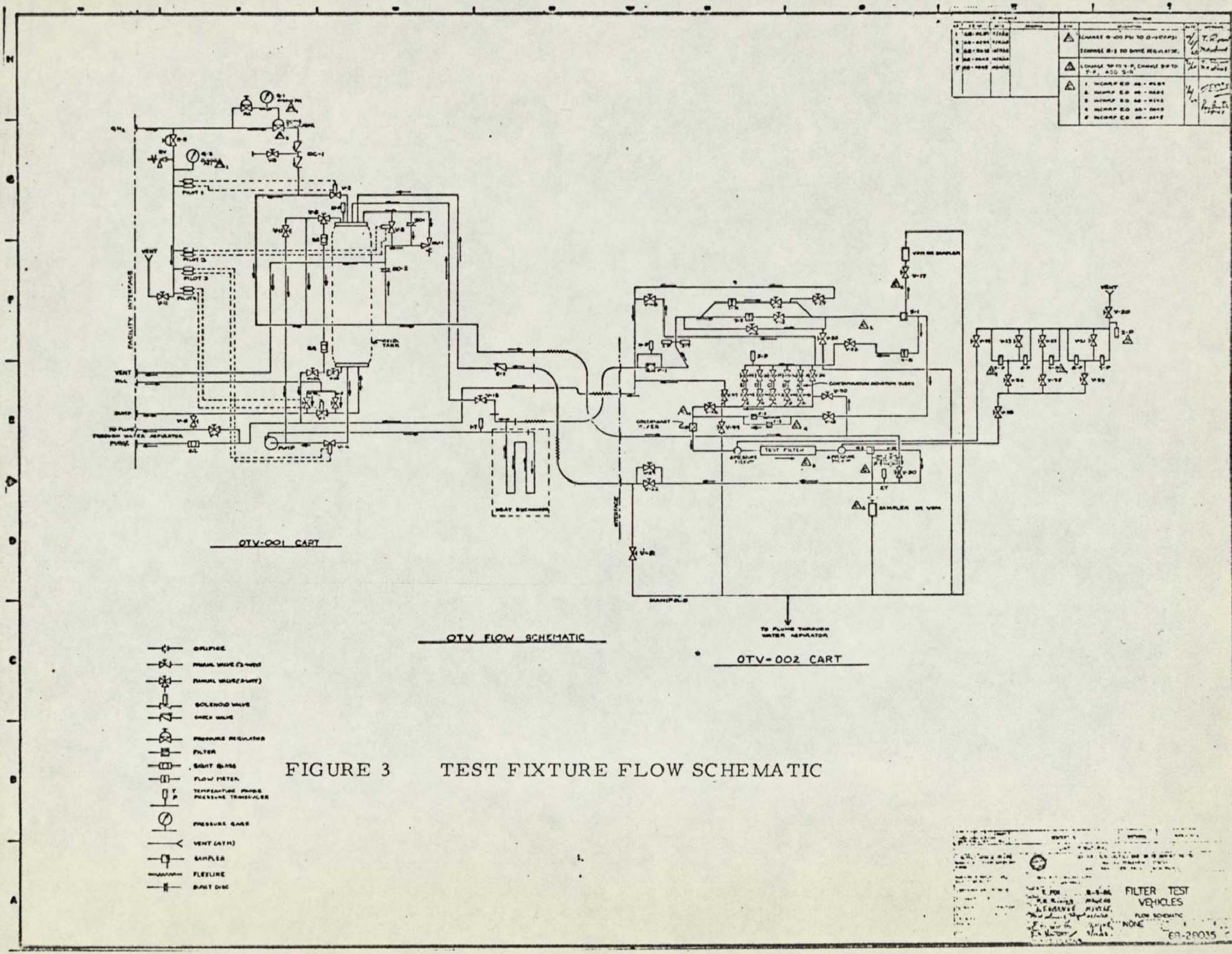


FIGURE 3 TEST FIXTURE FLOW SCHEMATIC

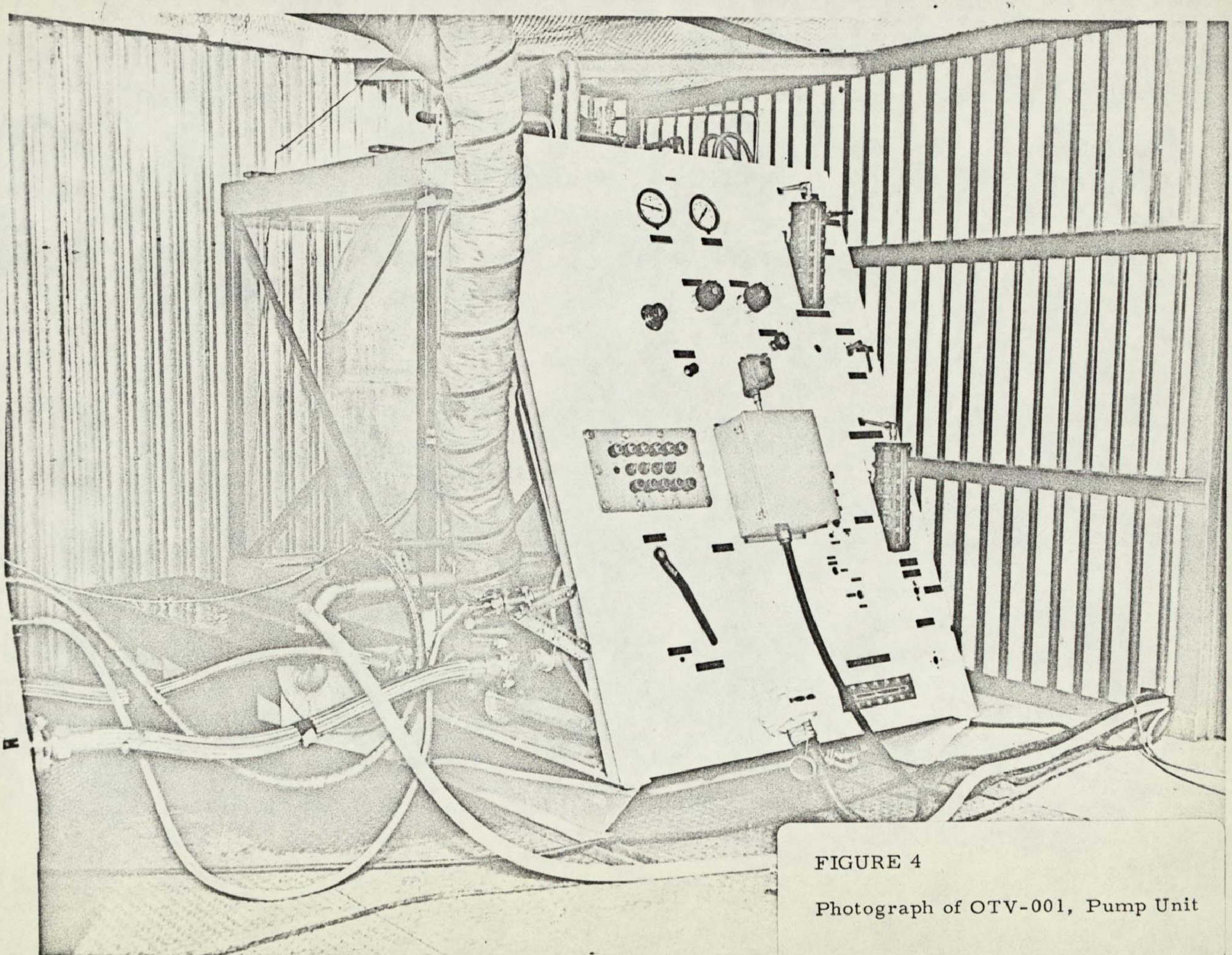


FIGURE 4

Photograph of OTV-001, Pump Unit

0169-0284

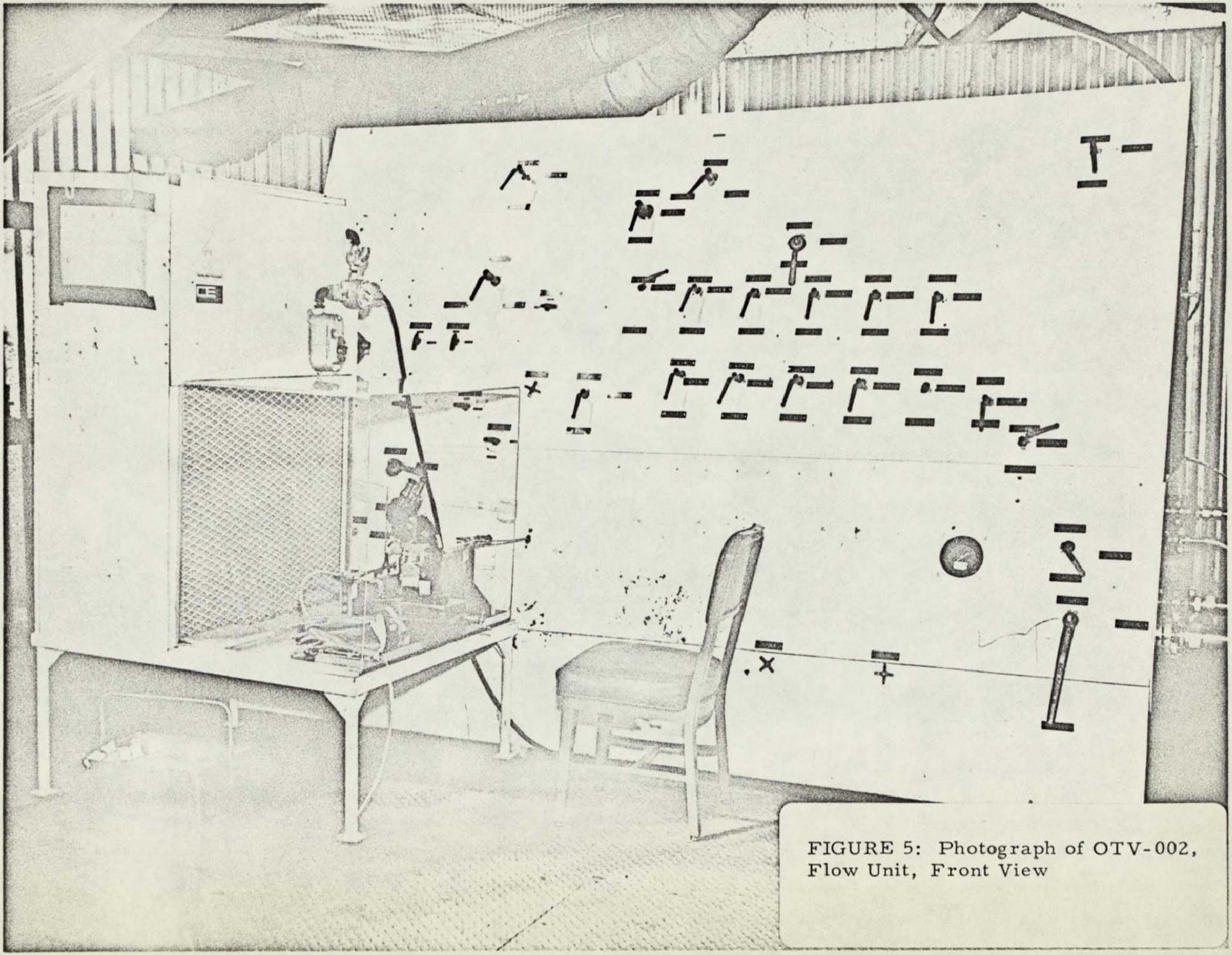


FIGURE 5: Photograph of OTV-002, Flow Unit, Front View

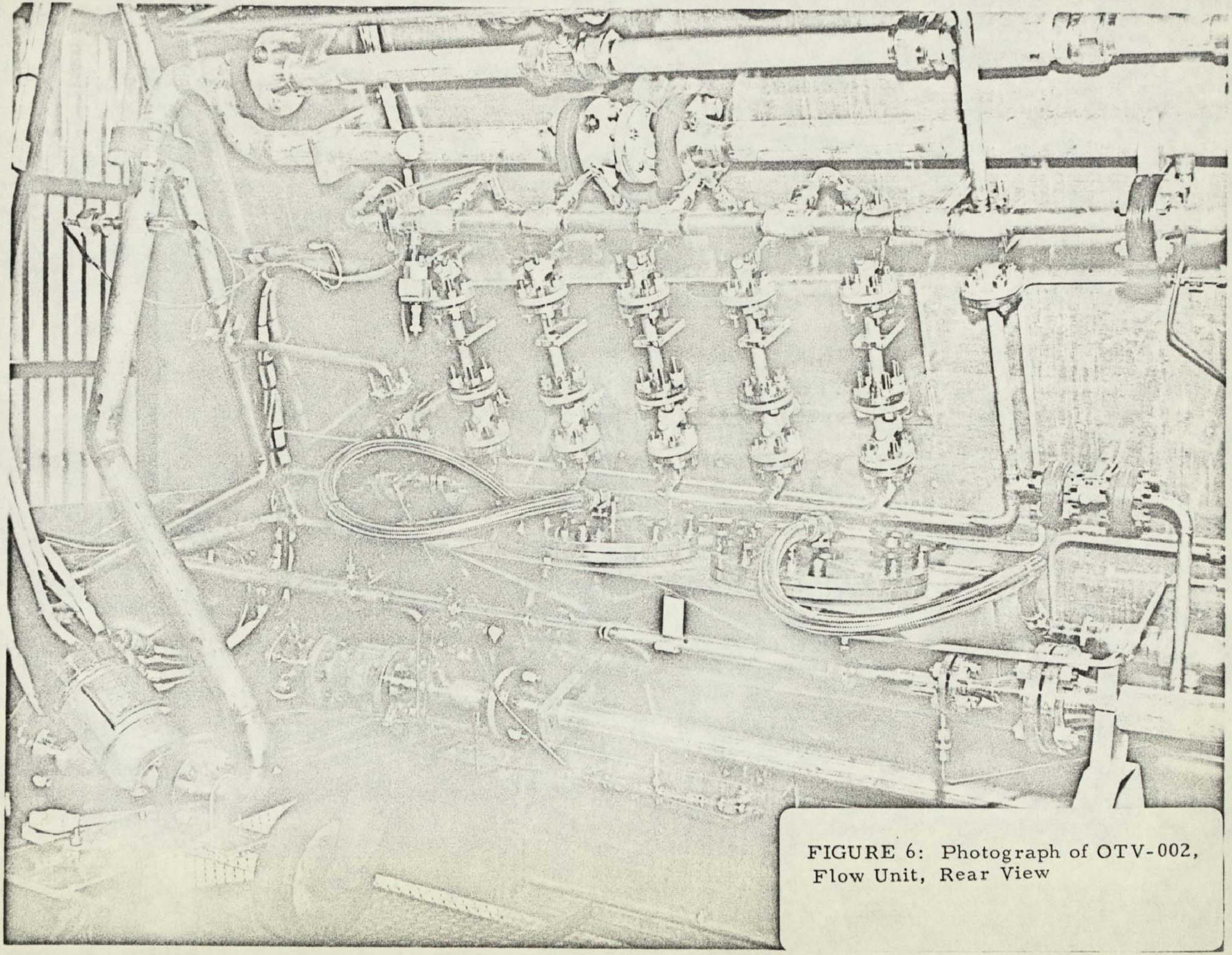


FIGURE 6: Photograph of OTV-002, Flow Unit, Rear View

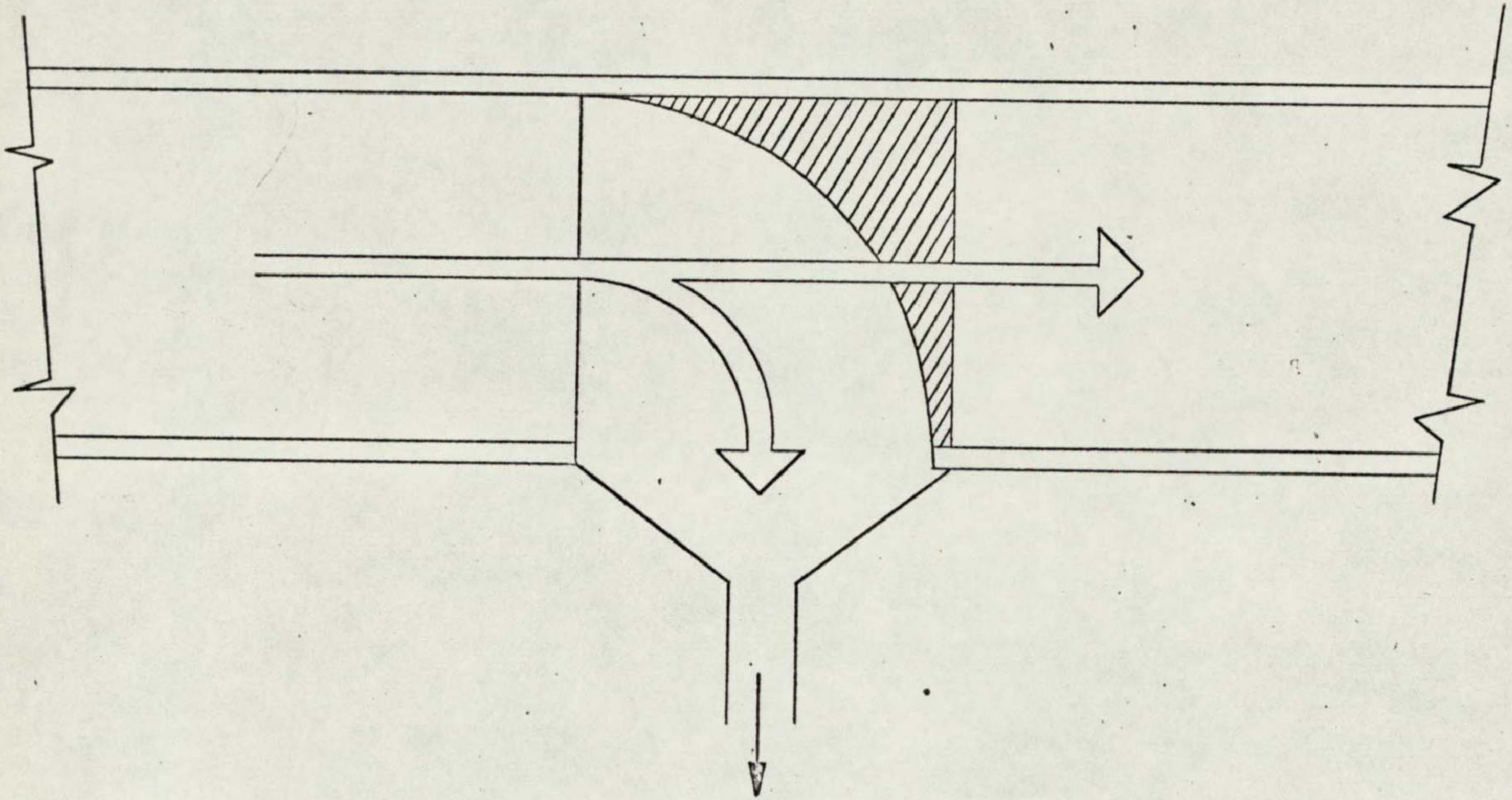


FIGURE 7 TYPICAL WYLE TYPE SAMPLING WEDGE

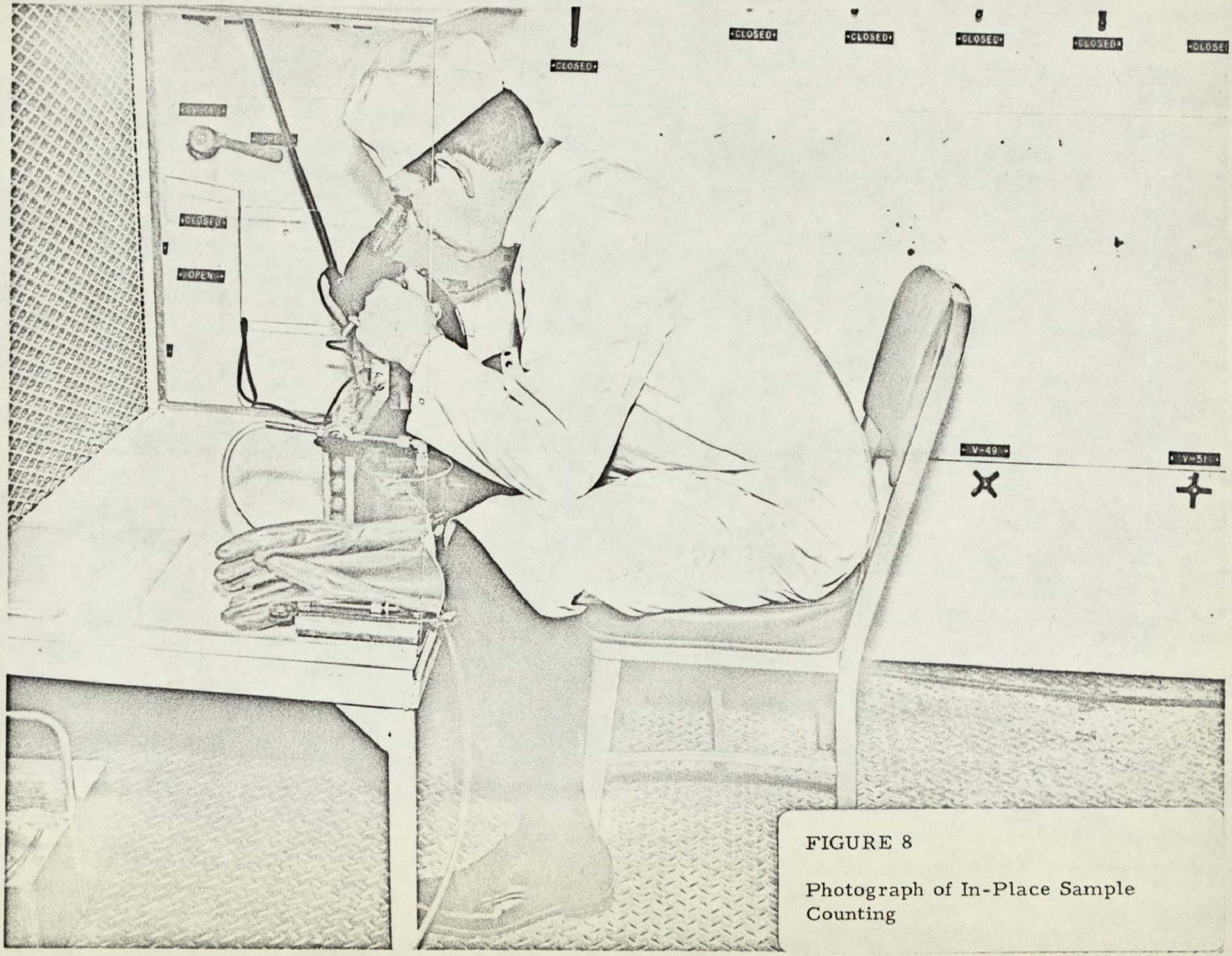


FIGURE 8

Photograph of In-Place Sample Counting

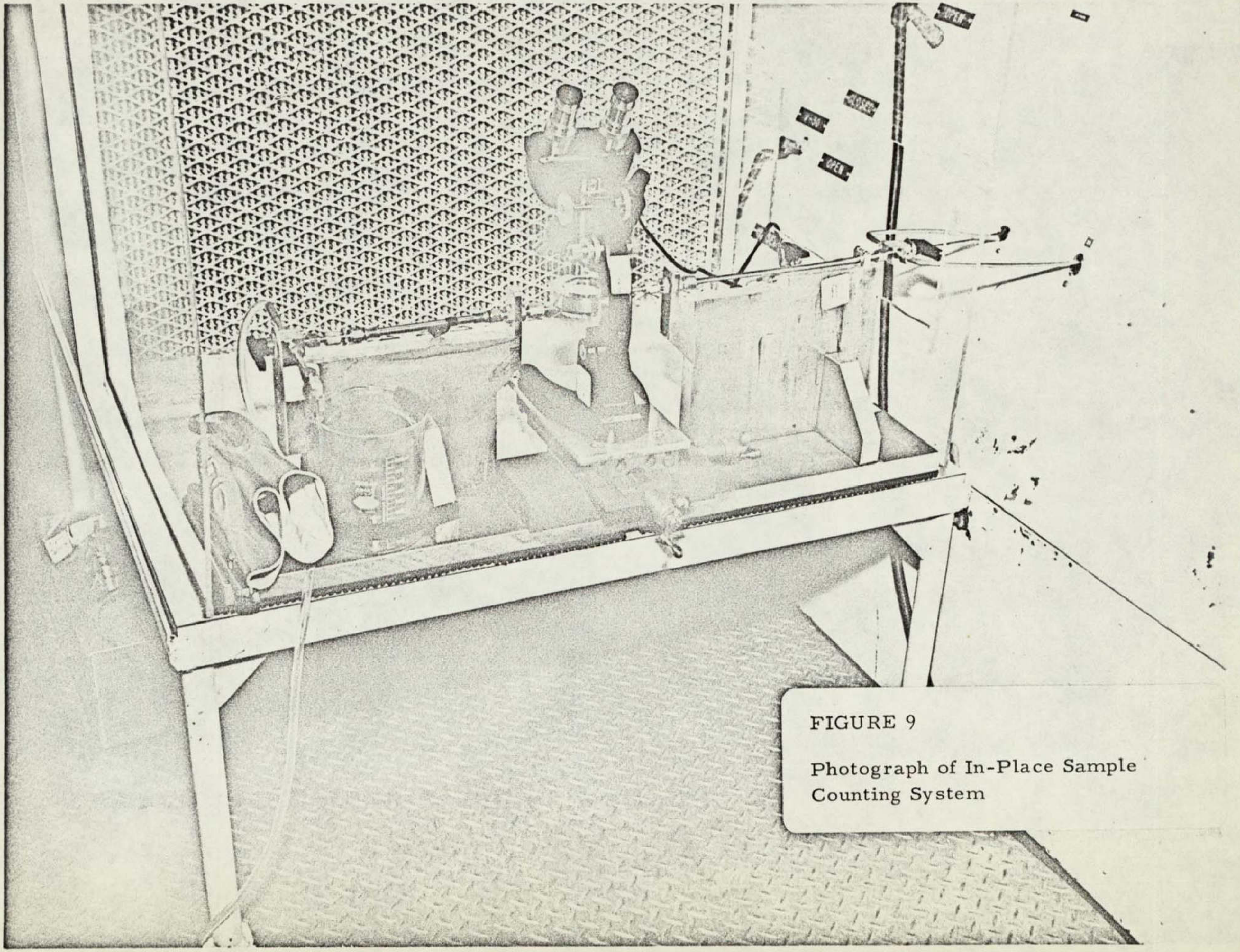


FIGURE 9

Photograph of In-Place Sample Counting System

SCHEMATIC OF INPLACE SAMPLE COUNTING SYSTEM

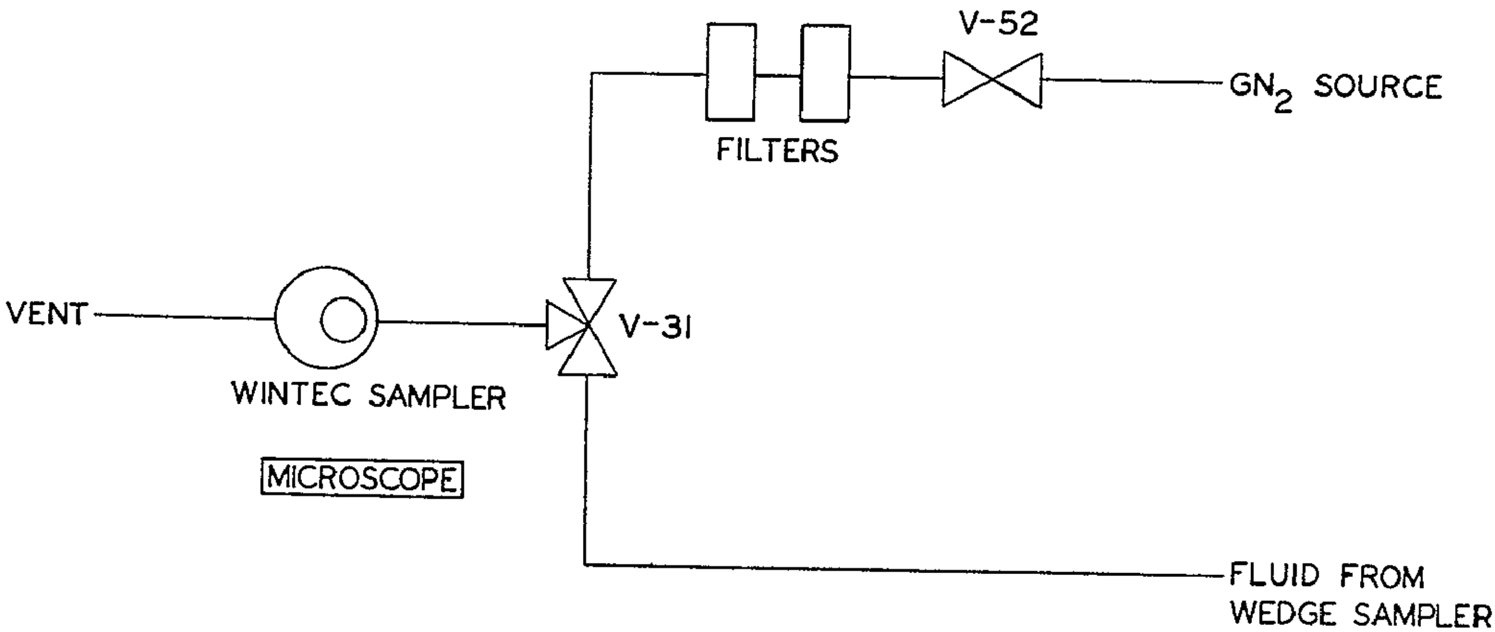


FIGURE 10.

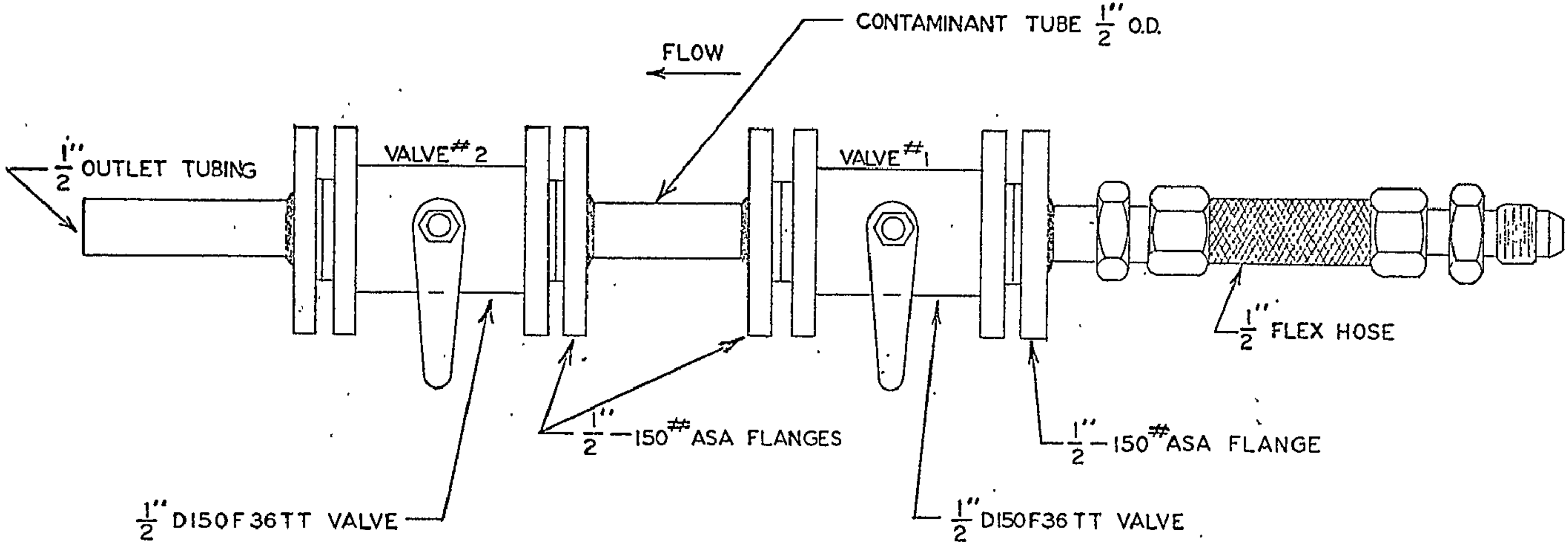
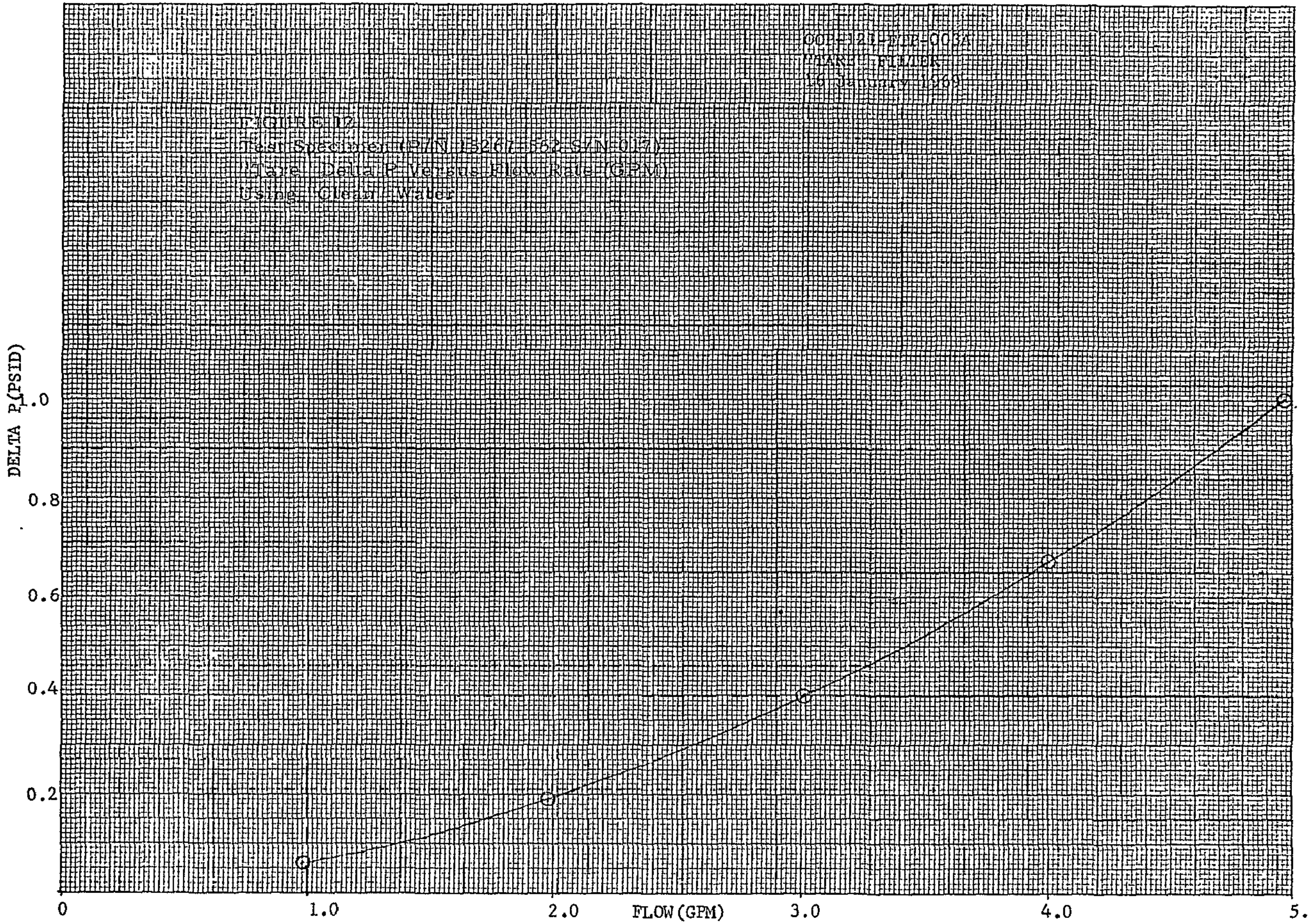
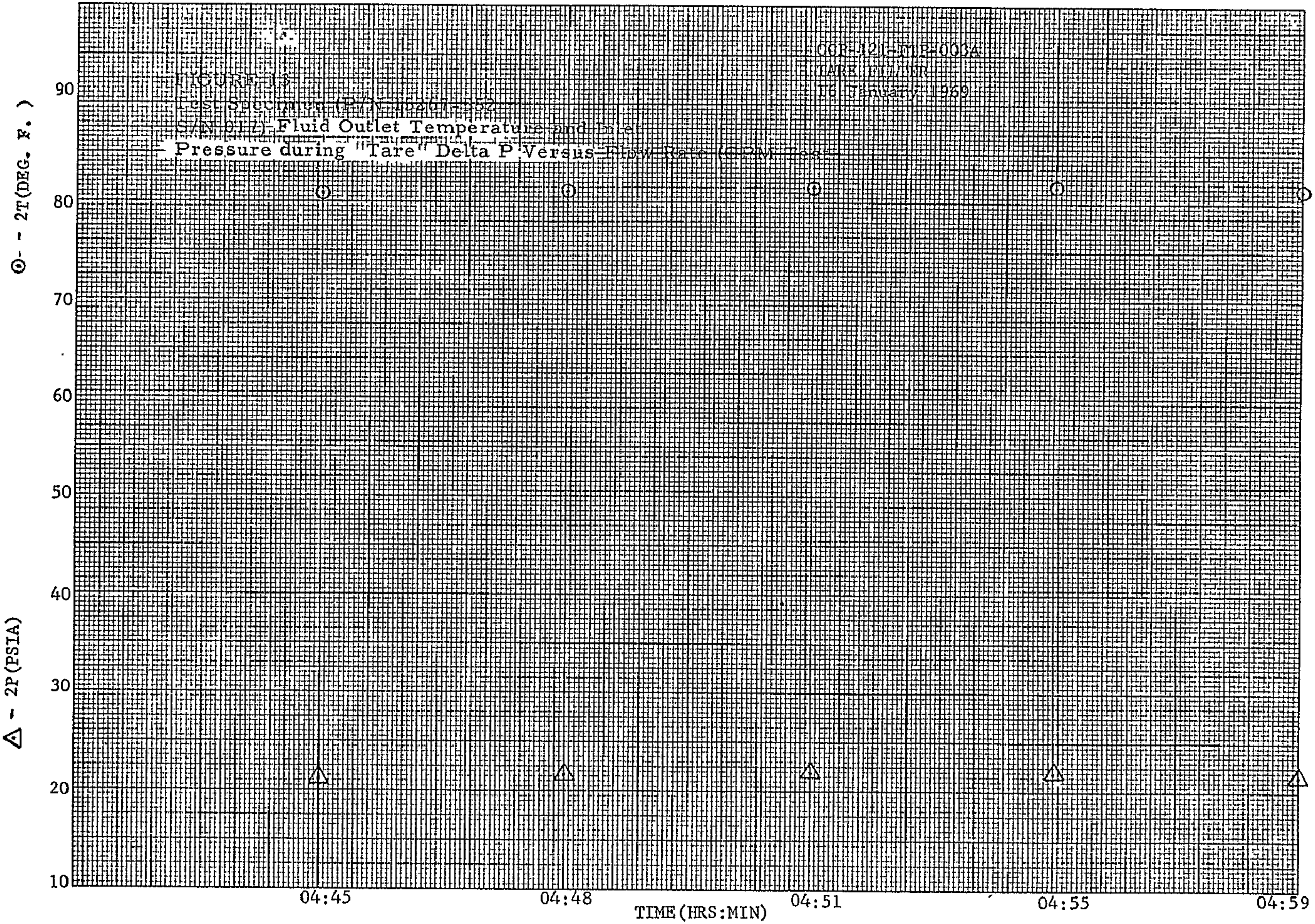


FIGURE 11 CONTAMINATION ADDITION SYSTEM


TARE FILTER
16 January 1969
FIGURE 12
Test Specimen (P/N 15267-562 S/N 017)
Tare Delta P Versus Flow Rate (GPM)
Using Clean Water
DELTA P (PSID)
1.0
0.8
0.6
0.4
0.2
0
1.0
2.0
FLOW (GPM)
3.0
4.0
5.0


16 January 1969
Fluid Outlet Temperature
Pressure during "Tare" Delta P Versus
⊙ - 2T(DEG. F.)
△ - 2P(PSIA)
90
80
70
60
50
40
30
20
10
04:45
04:48
04:51
04:55
04:59
TIME (HRS:MIN)

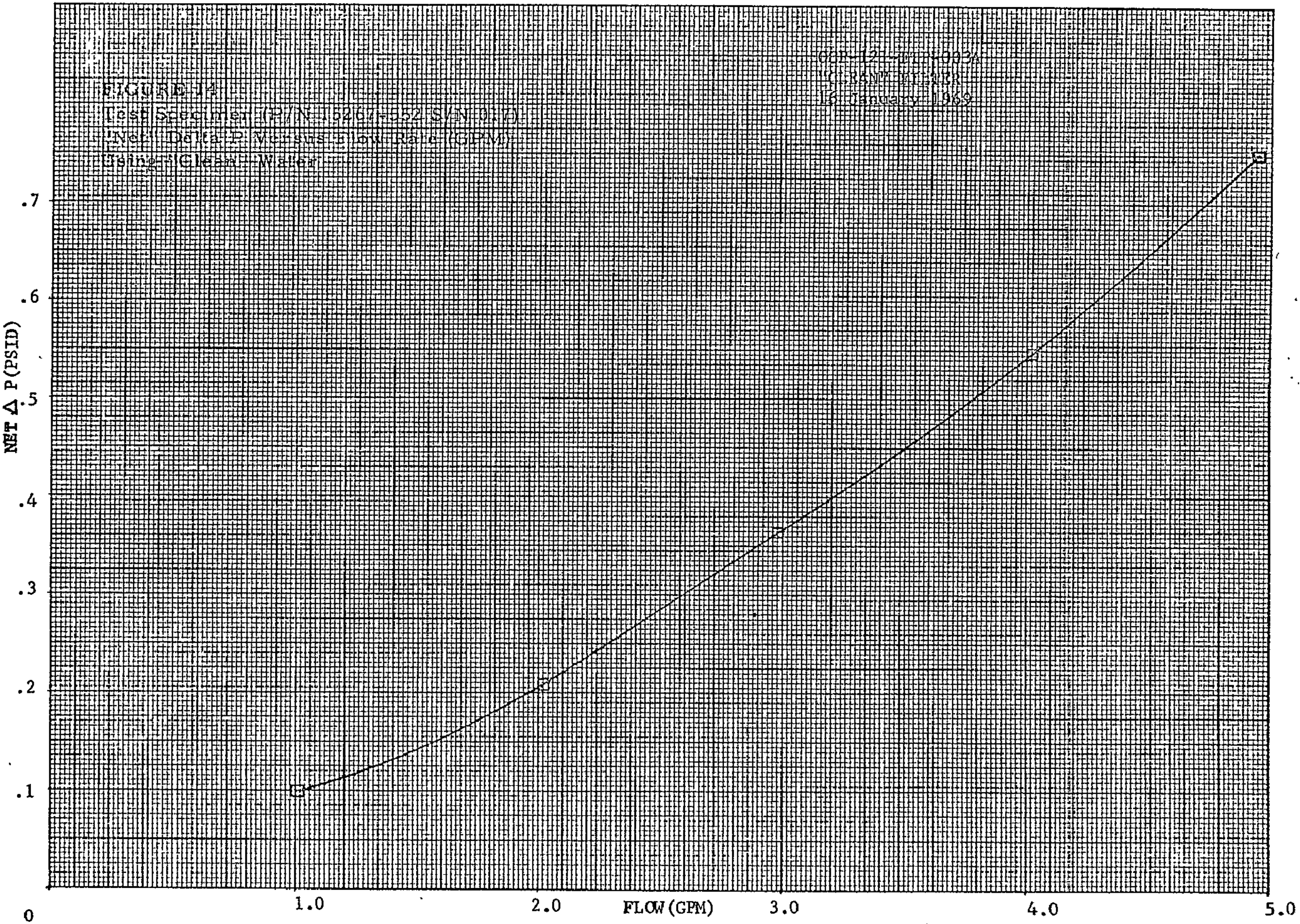


FIGURE 14
Test Specimen (P/N 15267-552 S/N 017)
"Net" Delta P Versus Flow Rate (GPM)
Using "Clean" Water
16 January 1969
NET Δ P (PSID)
.1
.2
.3
.4
.5
.6
.7
0
1.0
2.0
FLOW (GPM)
3.0
4.0
5.0


FIGURE 15
Fluid Outlet Temperature and Inlet Pressure
during "Net" Delta P Versus Flow Rate (GPM)
Using "Clean" Water
"CLEAN" FILTER
16 January 1969
⊙ - 2T (DEG. F)
△ - 2P (PSIA)
90
80
70
60
50
40
30
20
10
09:04
09:20
09:29
09:36
09:45
TIME (HRS:MIN)

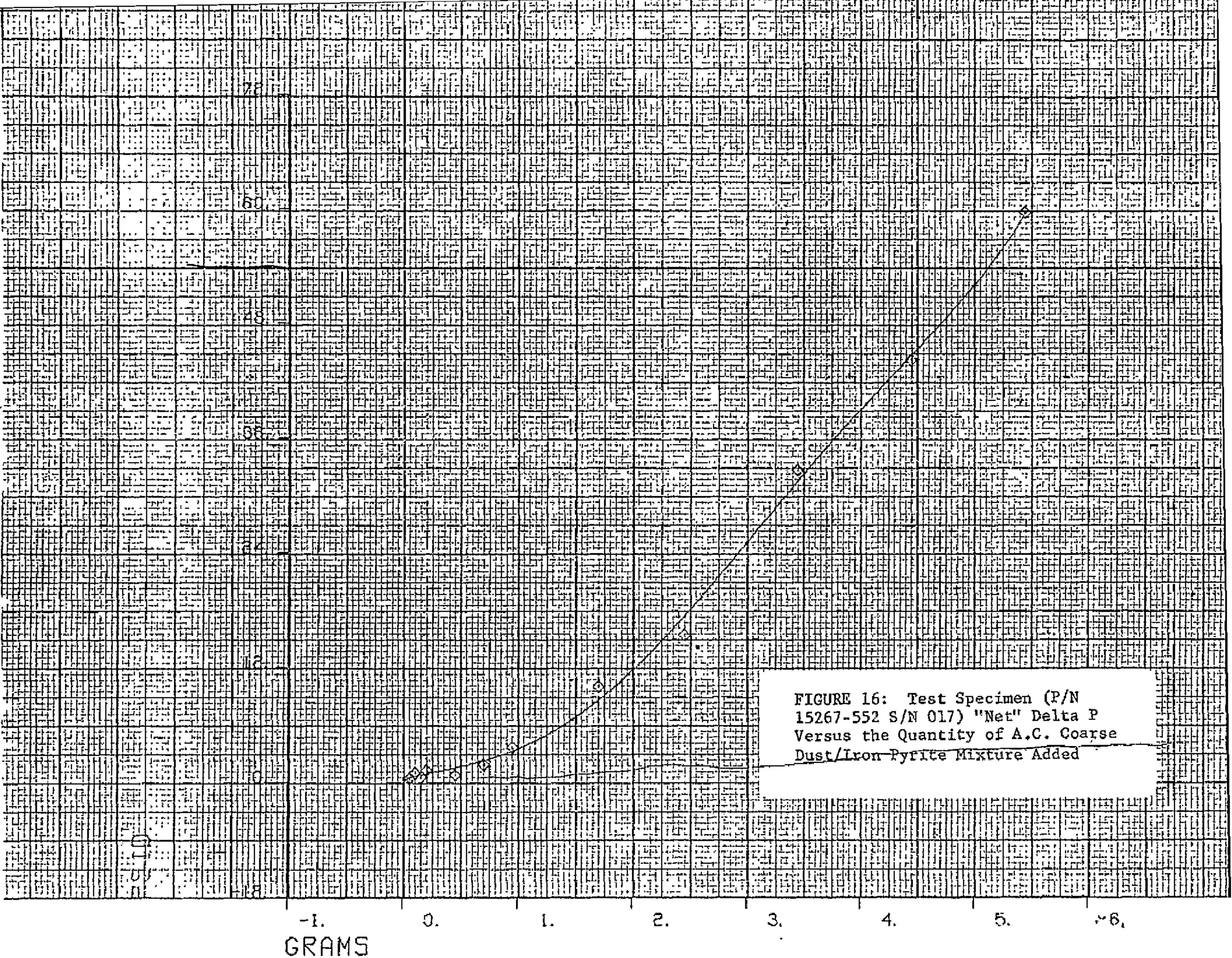


FIGURE 16: Test Specimen (P/N 15267-552 S/N 017) "Net" Delta P Versus the Quantity of A.C. Coarse Dust/Iron Pyrite Mixture Added

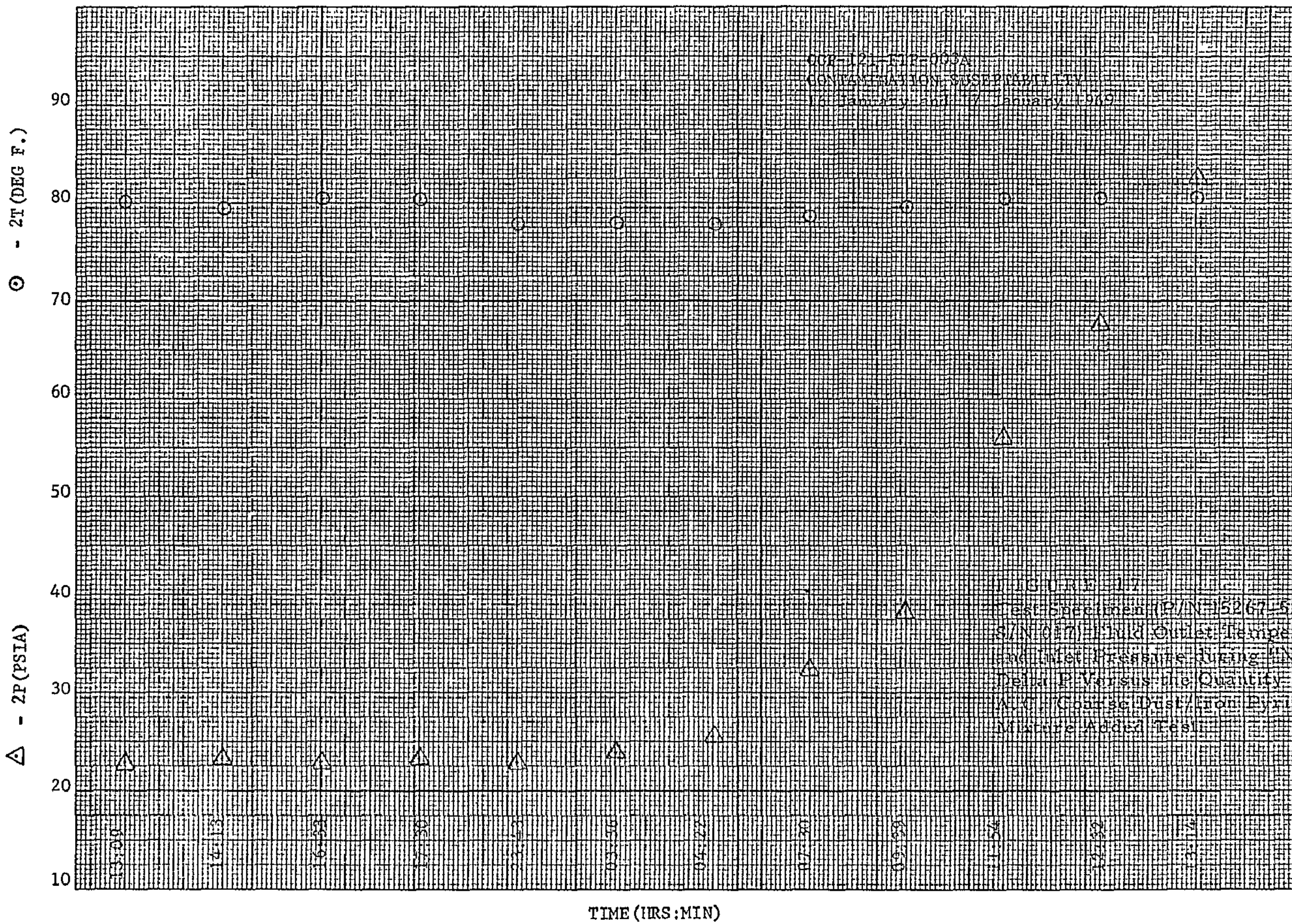


FIGURE 17
Test Specimen (P/N 15267-552 S/N 017) Fluid Outlet Temperature and Inlet Pressure during "Net" Delta P Versus the Quantity of A.C. Coarse Dust/Iron Pyrite Mixture Added Test

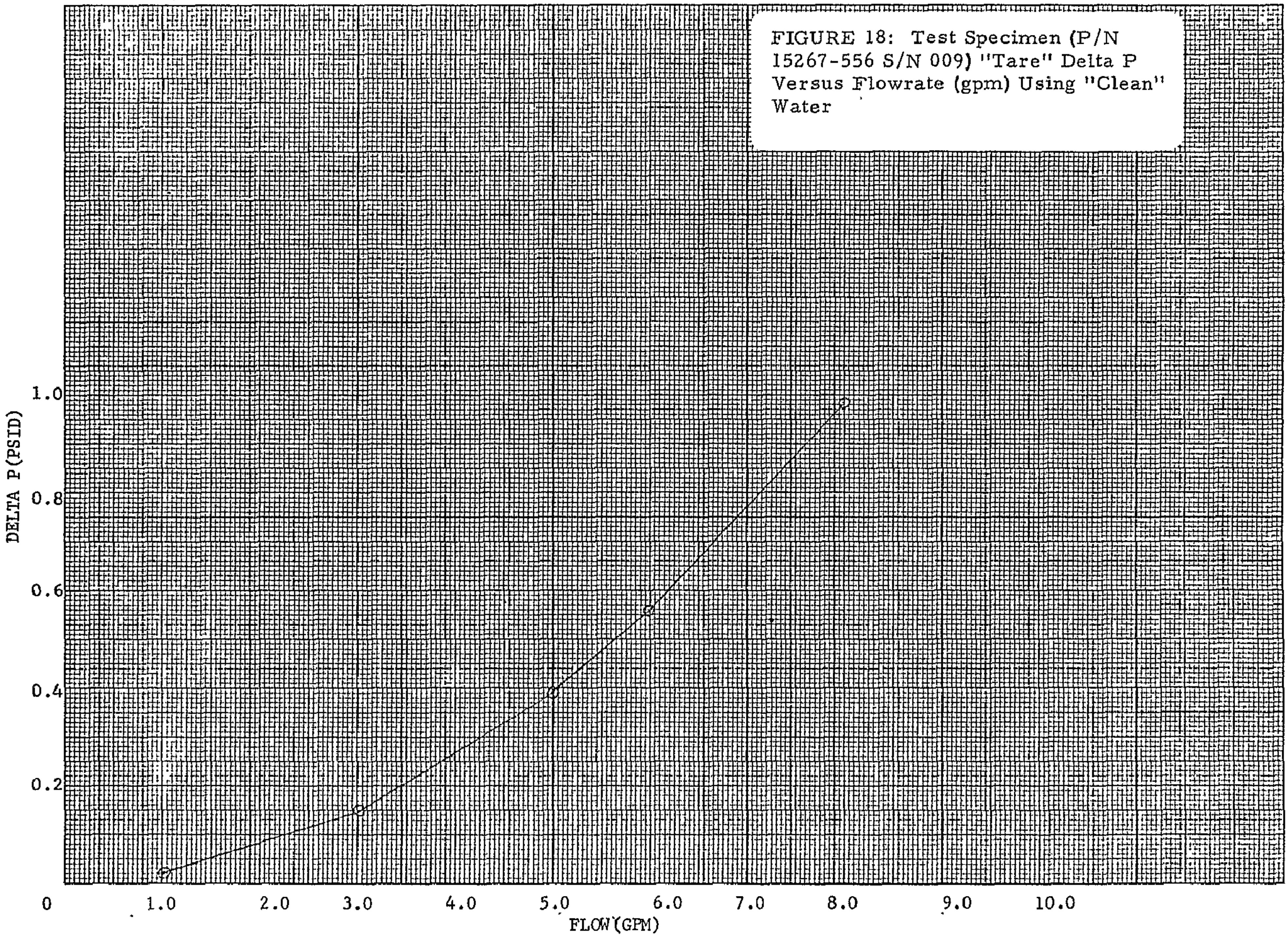


FIGURE 18: Test Specimen (P/N 15267-556 S/N 009) "Tare" Delta P Versus Flowrate (gpm) Using "Clean" Water

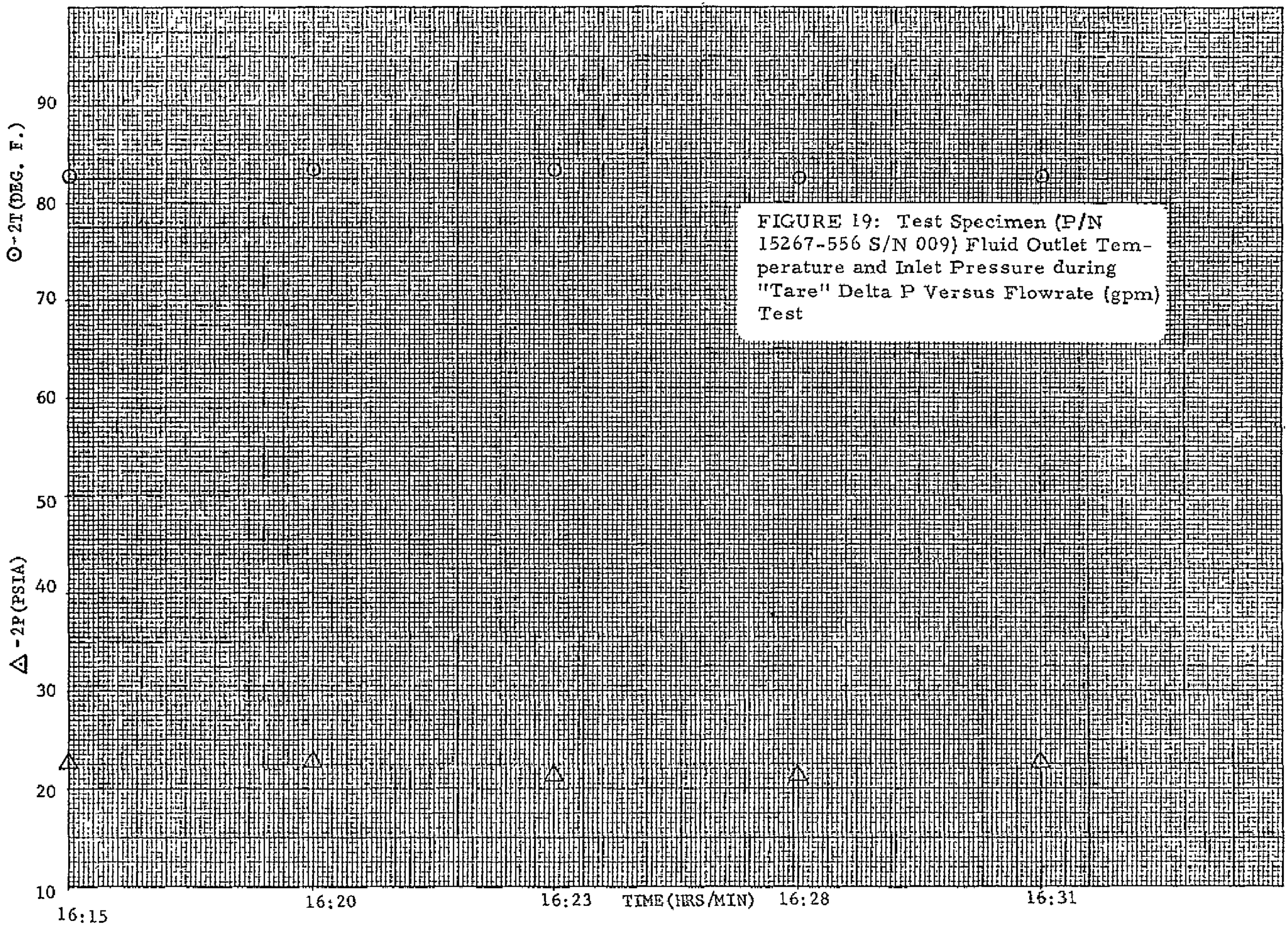


FIGURE 19: Test Specimen (P/N 15267-556 S/N 009) Fluid Outlet Temperature and Inlet Pressure during "Tare" Delta P Versus Flowrate (gpm) Test

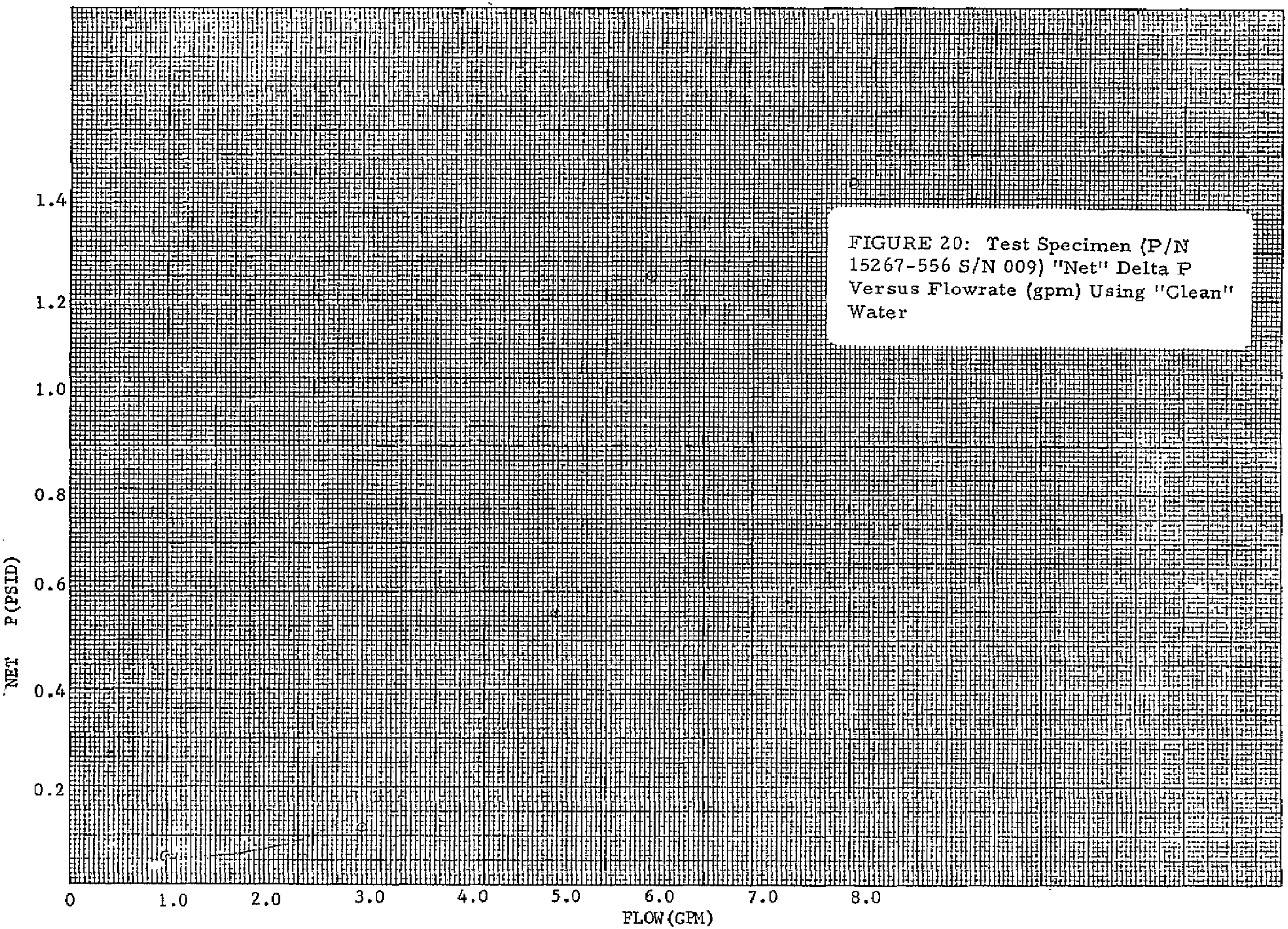


FIGURE 20: Test Specimen (P/N 15267-556 S/N 009) "Net" Delta P Versus Flowrate (gpm) Using "Clean" Water

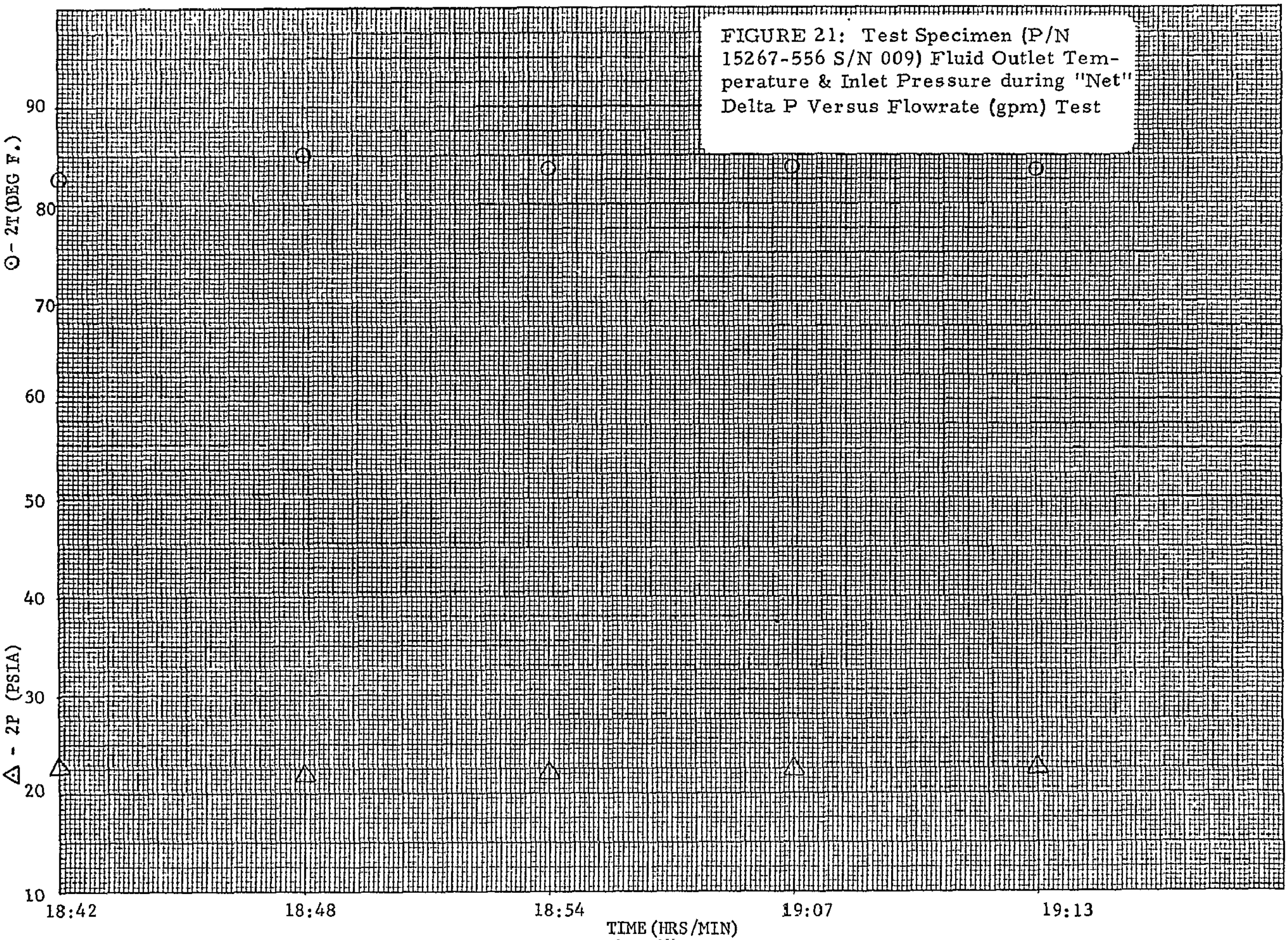


FIGURE 21: Test Specimen (P/N 15267-556 S/N 009) Fluid Outlet Temperature & Inlet Pressure during "Net" Delta P Versus Flowrate (gpm) Test
⊙ - 2T (DEG F.)
△ - 2P (PSIA)
90
80
70
60
50
40
30
20
10
18:42
18:48
18:54
19:07
19:13
TIME (HRS/MIN)

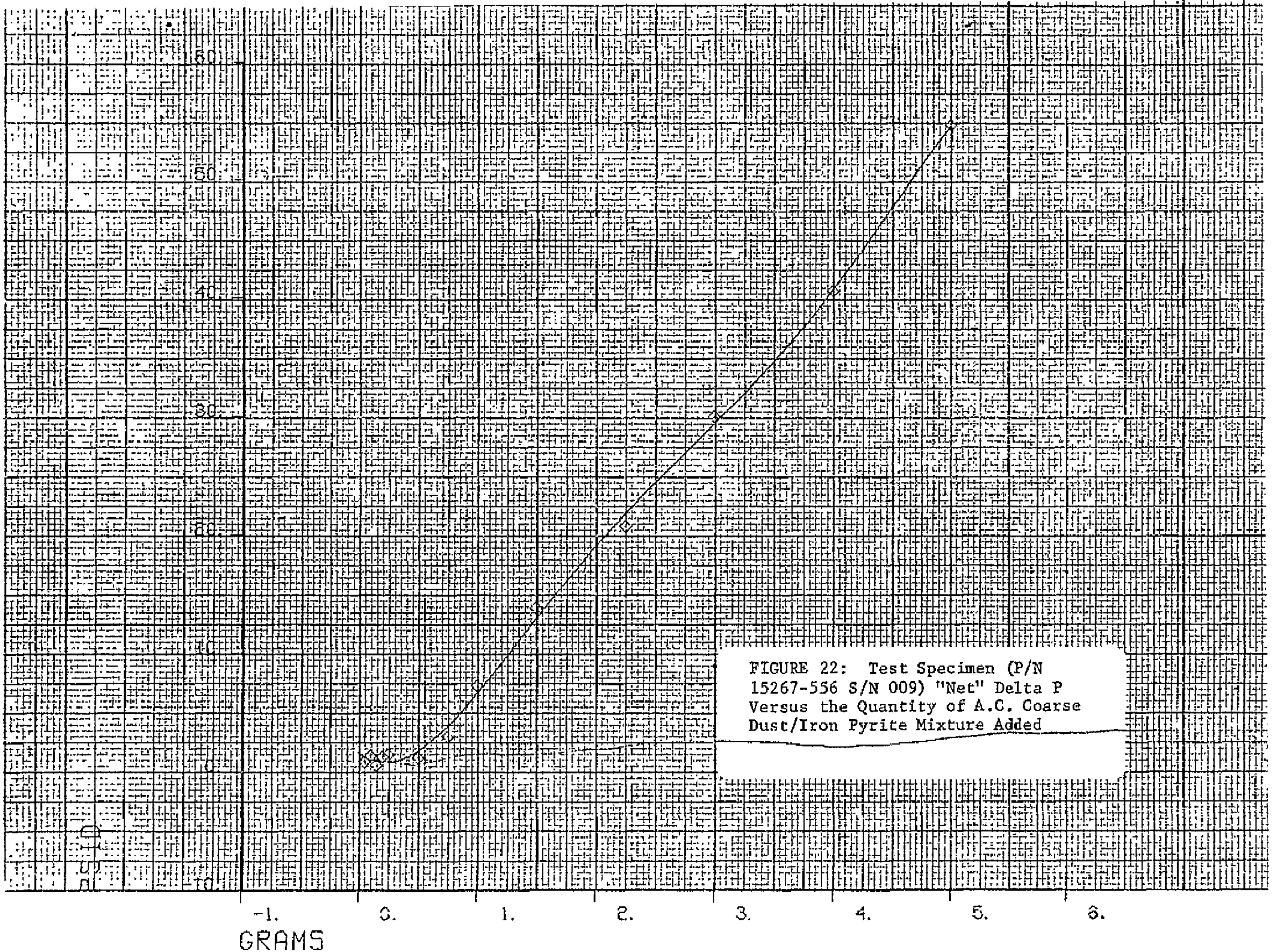


FIGURE 22: Test Specimen (P/N 15267-556 S/N 009) "Net" Delta P Versus the Quantity of A.C. Coarse Dust/Iron Pyrite Mixture Added

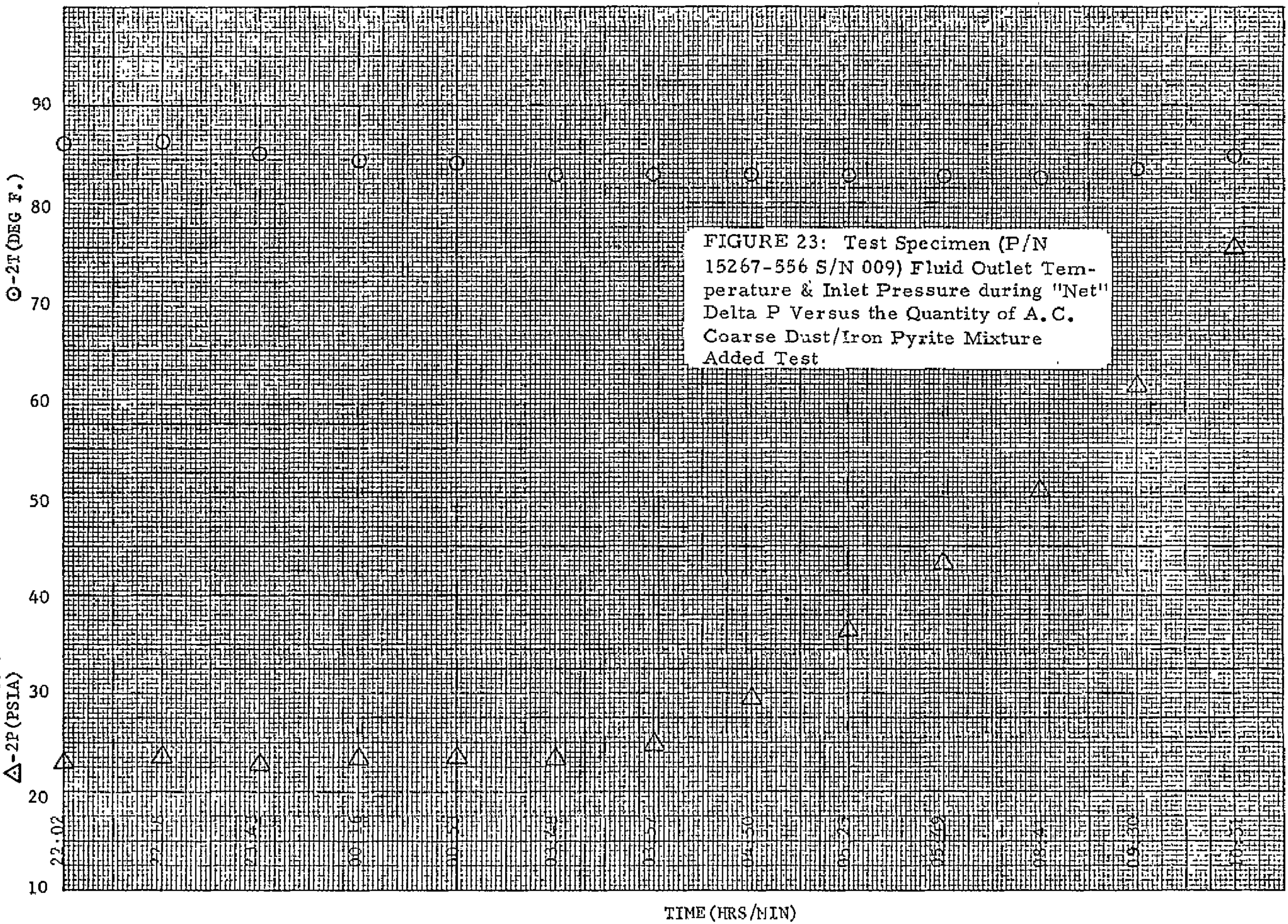


FIGURE 23: Test Specimen (P/N 15267-556 S/N 009) Fluid Outlet Temperature & Inlet Pressure during "Net" Delta P Versus the Quantity of A.C. Coarse Dust/Iron Pyrite Mixture Added Test

FIGURE 24 Typical Non-Iron Pyrite Particles Observed during the Test

FIGURE 25 Typical Non-Iron Pyrite Particles Observed during the Test

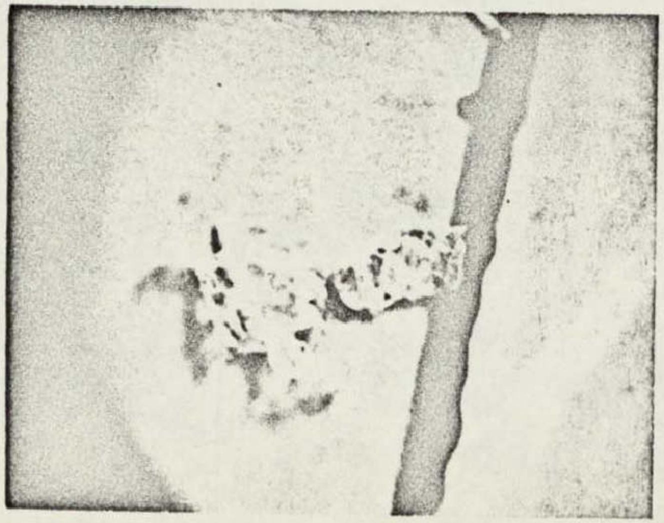


FIGURE 26 Particulate Observed during Laboratory Tests on Whitey 3-Way Valve

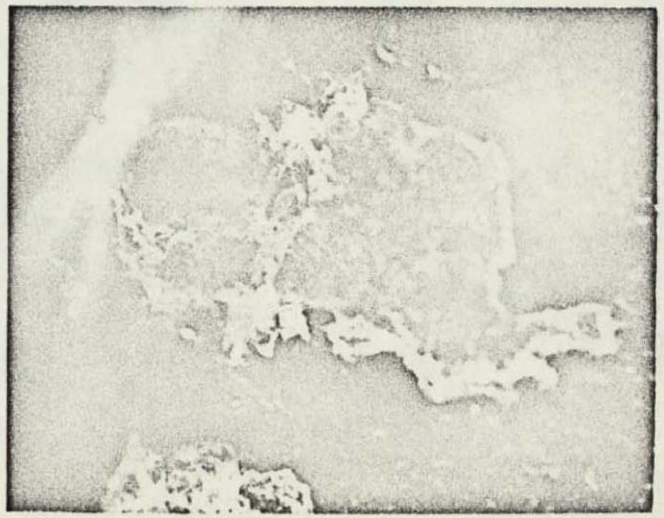


FIGURE 28 Photograph of Particulate on Surface of Metal Valve Insert

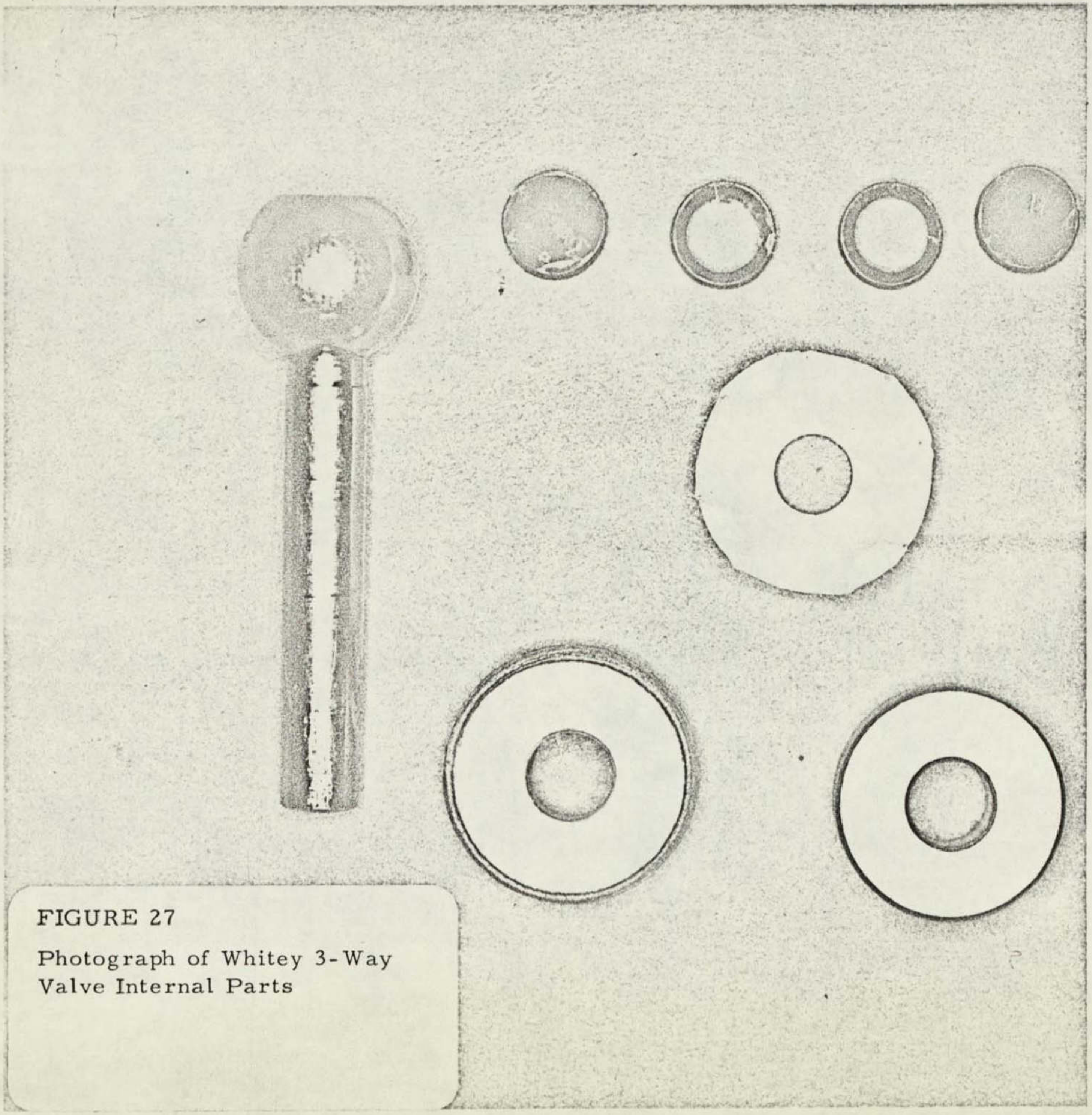


FIGURE 27

Photograph of Whitey 3-Way Valve Internal Parts

NO SERIAL NUMBER

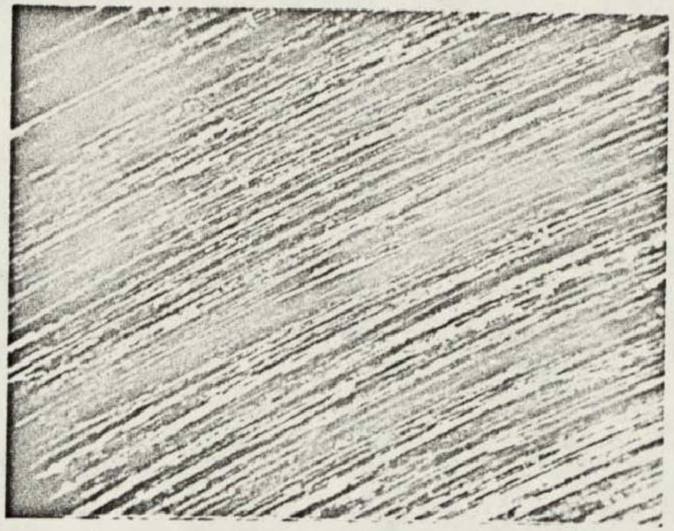


FIGURE 29 Microscopic Photograph of Ledge in Wintec Sampler

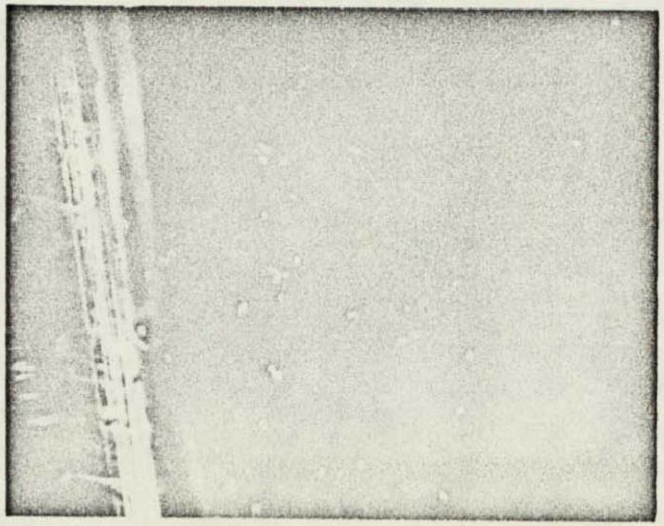


FIGURE 30 Microscopic Photograph of Underside of Wintec Glass Cover

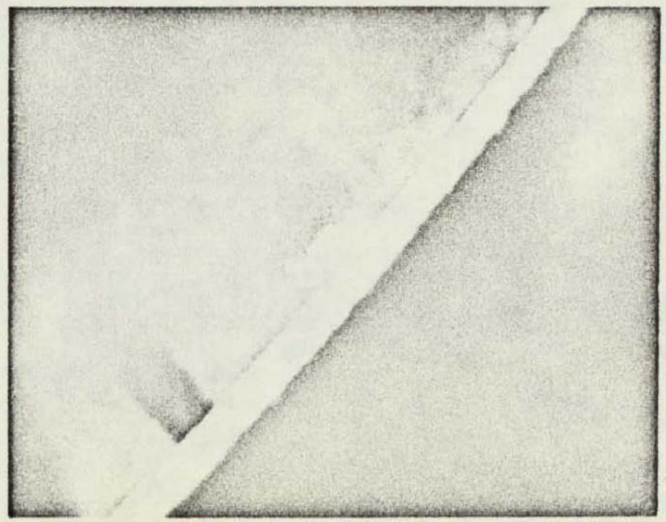
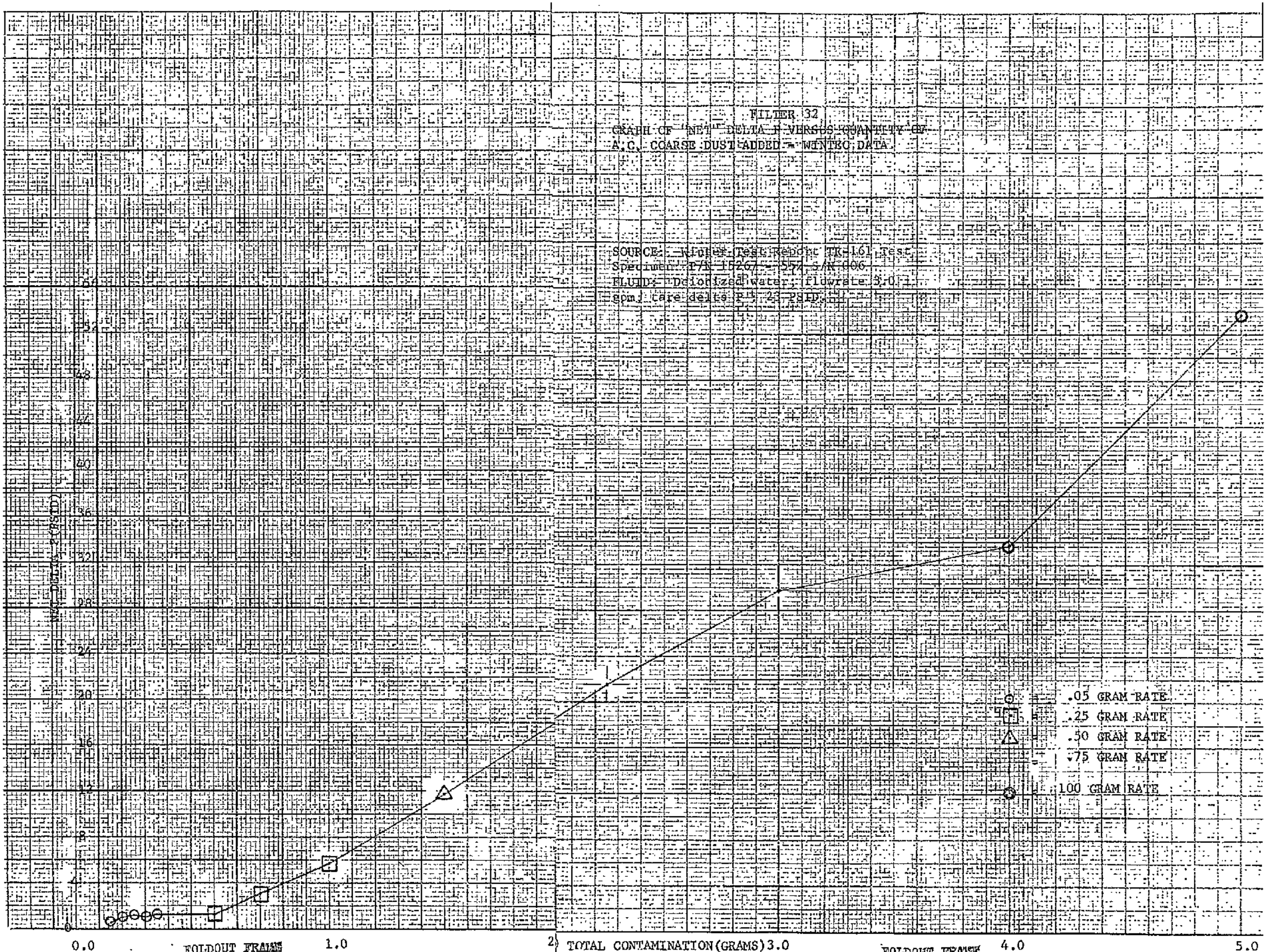


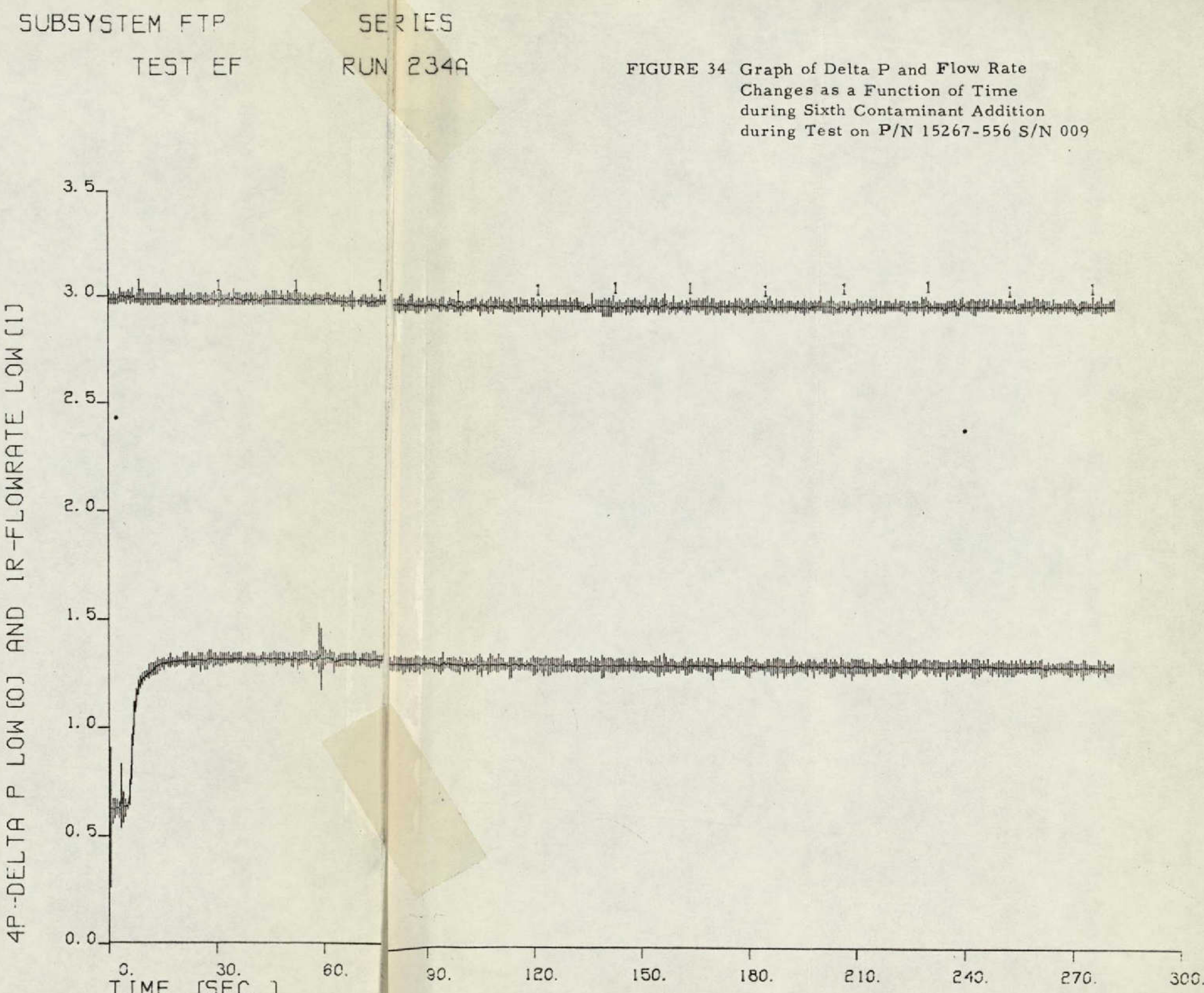
FIGURE 31 Microscopic Photograph of Verticle Surface of Ledge in Wintec Sampler



FOLDOUT FRAME

FOLDOUT FRAME

FIGURE 34 Graph of Delta P and Flow Rate Changes as a Function of Time during Sixth Contaminant Addition during Test on P/N 15267-556 S/N 009



FOLDOUT FRAME

FOLDOUT FRAME

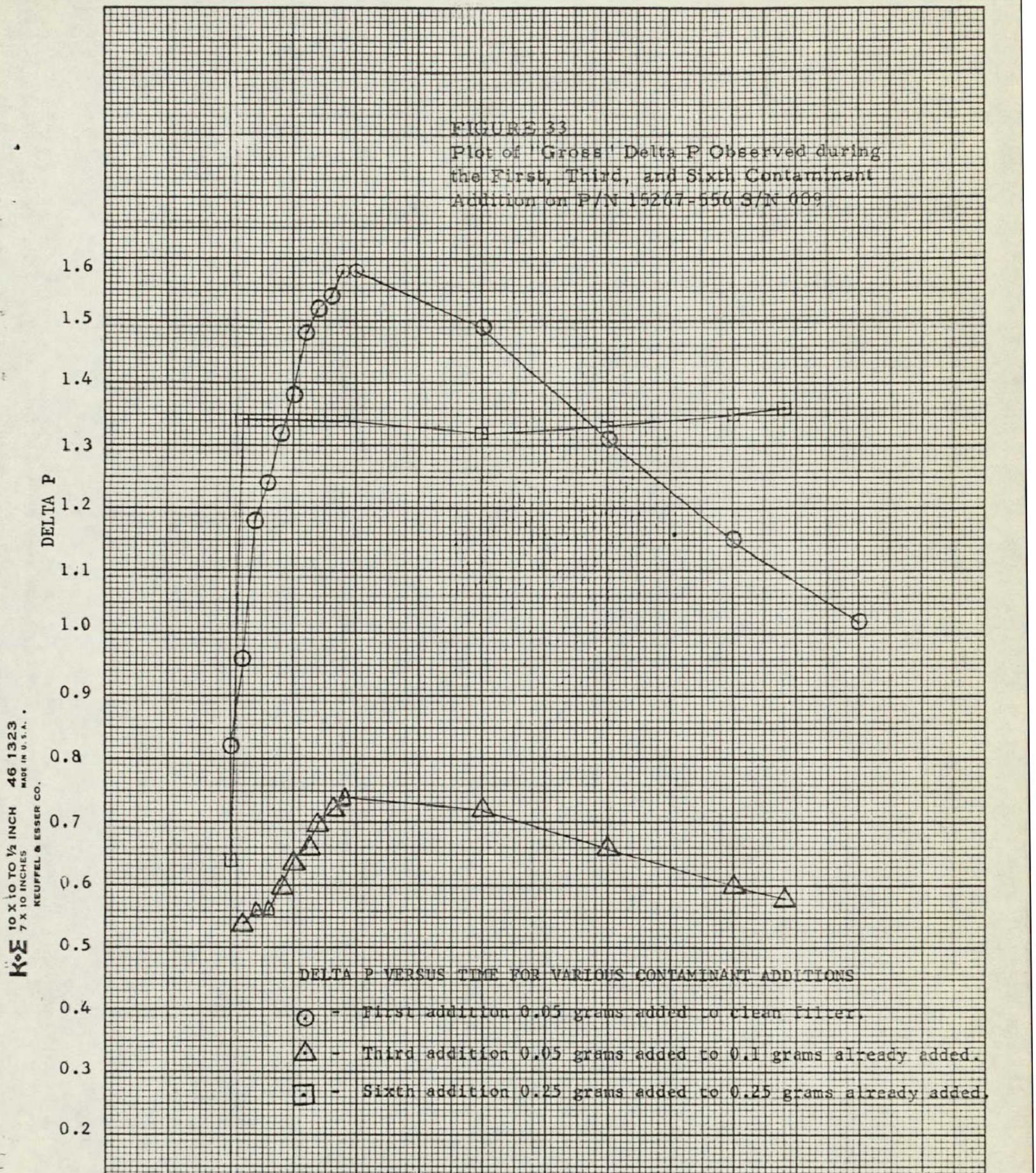


FIGURE 33
Plot of 'Gross' Delta P Observed during the First, Third, and Sixth Contaminant Addition on P/N 15267-556 S/N 009
DELTA P
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5
10
15
20
25
TIME (MIN)
DELTA P VERSUS TIME FOR VARIOUS CONTAMINANT ADDITIONS
- First addition 0.05 grams added to clean filter.
- Third addition 0.05 grams added to 0.1 grams already added.
- Sixth addition 0.25 grams added to 0.25 grams already added.
FIGURE 33
K&E 10 X 10 TO 1/2 INCH 7 X 10 INCHES 46 1323 KEUFFEL & ESSER CO. MADE IN U.S.A.

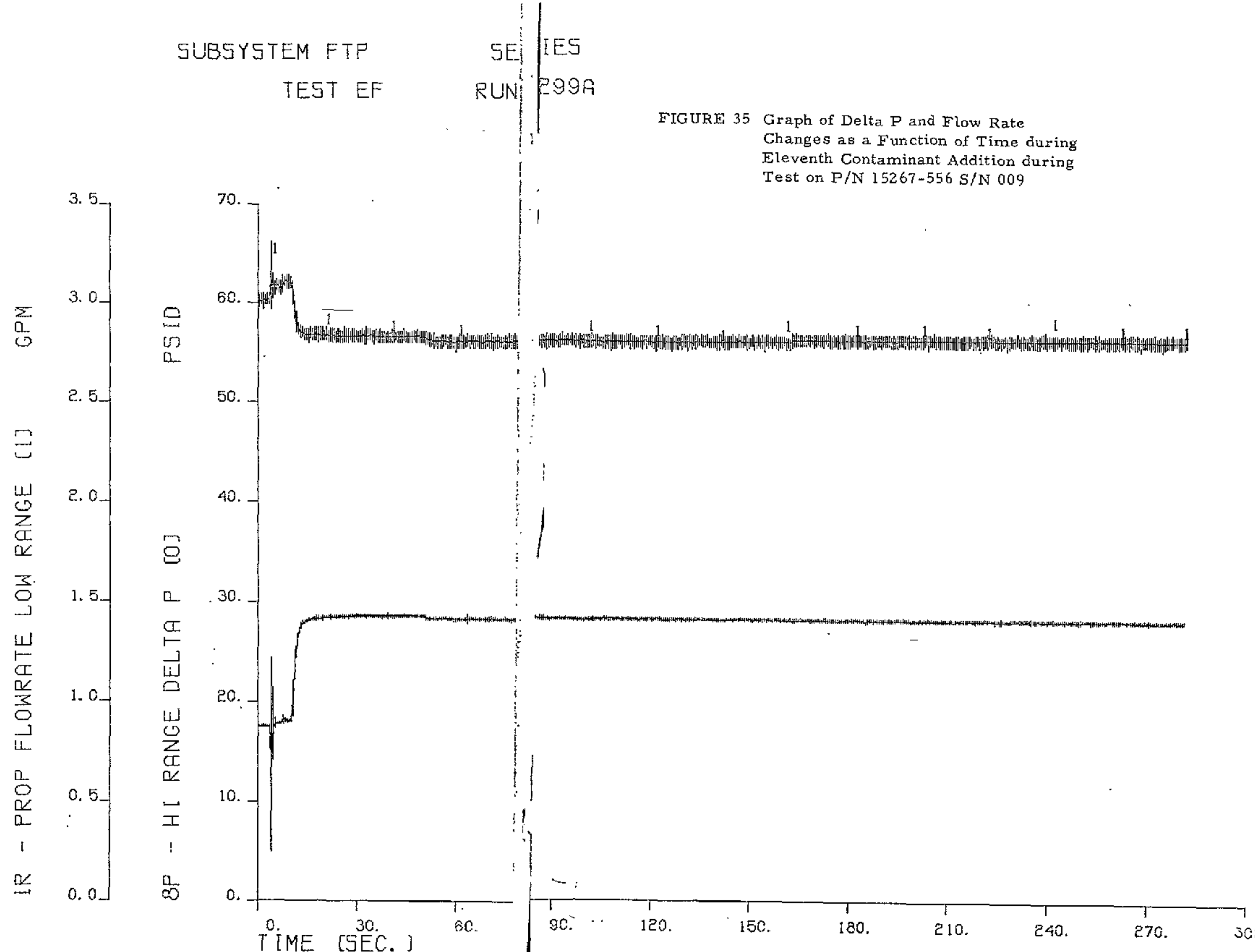


FIGURE 35 Graph of Delta P and Flow Rate Changes as a Function of Time during Eleventh Contaminant Addition during Test on P/N 15267-556 S/N 009

FOLDOUT FRAME

FOLDOUT FRAME